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McKay
The photographic negative.

THE PHOTOGRAPHIC NEGATIVE

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by

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SPECIAL METHODS

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Special Methods

ORDINARILY we should regard "special methods" as something to be used in infrequent emergencies, but in photography special methods are almost the normal methods. Normal photography as distinct from special photography is confined quite largely to the casual snapshooting of the beginner. As soon as the amateur begins to recognize the unlimited possibilities of photography, he starts working in those fields which demand special methods.

Because special methods are so widely used, it would be impossible to discuss each in full detail within a limited space. Instead of attempting that, we shall endeavor to cover the general techniques of those methods which find the most common application.

The use of a special technique often involves the use of special materials or equipment. For example, among special materials we find the less commonly used emulsions, such as positive or color-blind film; the process films, including process panchromatic and

the "M" emulsion made especially for photomicrography; the infrared and other special types. Such films as commercial and portrait can hardly be classed as "special."

Among special equipment we have such types of cameras as photomicrographic, bibliographic, telephoto, fingerprint, and a host of others. Lenses are available in such a great variety that they lose their novelty, and almost any lens is now regarded as a normal lens. Then there are lens extension tubes, supplementary lenses, contrast filters, and other optical accessories. Special chemicals include several types of developers, some variation in fixers, intensifiers and reducers, toners, tints, blocking dyes, and so forth. Most of these have already been considered in their general aspects.

Special technical procedures include the use of colored light, polarized light, special masks (opaque and translucent), the step process in which a series of positives and negatives is used for intensification, negative-positive combinations for bas-relief, cutouts for montage, and other processes which we shall deal with in proper order.

Copying.

The first special technique we shall consider is that of copying. To the experienced photographer copying is simply straight photography with nothing special about it; but the fact that general opinion has it that a copy must always be inferior to the original is evidence that good copy technique is decidedly "special."

To start with, one important fact should be recognized. Unless the original print is of very good quality, it is possible to make the copy **better** than the original. Often the copy will have a tonal range which is greater

than that of the original. In other words, it is possible to pick up shadow detail which is lost in the original print. The aim in copying is to preserve everything in the original and to add to it whenever desirable and possible.

Copying is simply making a photograph of another photograph, of any type of picture, painting, etching, or other graphic representation. Ordinarily letterpress, books, documents, maps, plans, and so forth are included, but this is incorrect. The photography of such originals falls properly within the province of **biblio-photography.** As we shall see, this branch of photography is truly documentary photography, but as that name has been appropriated to a vague and meaningless subdivision of photography, the use of this accurate term produces confusion.

Before getting into the subject, it might be well to clarify the use of terms. An original to be copied is quite often referred to as the **copy.** The term "copy" is borrowed from the printing profession, where it is used to indicate an original to be reproduced. The resulting photograph, which many beginners refer to as "the copy," is really the **reproduction.** To avoid this confusing terminology in describing the technique of copying, we will refer to the material to be copied as the **original,** and to the result as the **reproduction.**

Any camera owner who understands the fundamentals of photography can make good copies. In fact, it is so easy that some schools make copying the first lesson in camera manipulation. This is in such direct contrast with the experience of many amateurs that we might ask why it is done. Two fundamentals of ordinary photography are eliminated in copying. The lighting is always of a single type—the flattest, most uniform which can be obtained. The other factor is that there is no depth of field, so that differential focusing and small lens apertures are not necessary.

Aside from these two points, copying is straight photography of the most elementary kind. Therefore, we shall discuss first the positive factors, and then proceed to the negative ones.

Lining Up Camera and Original.

The camera renders true perspective; therefore, if the photograph is to be a true reproduction of the original, the plane of the film must be exactly parallel to that of the original. This is often difficult to manage if the original is hung upon a wall and the camera, on an ordinary tripod, is placed facing it. Care should be taken in lining up camera and original so that horizontal and vertical lines are rendered correctly, and so that parallel lines do not converge.

If there is much copying to be done, a special copying stand should be made for the camera. This is a long bench with side rails, and sliding inside these rails a board upon which the camera is fastened. At the end of the bed a carefully squared easel is placed exactly perpendicular to the plane of the bed and to its axis. That is, the easel is square, both up and down and from side to side, with the camera bed. If there is some doubt as to the accuracy of the positioning, when using a camera with a groundglass focusing screen, the image upon the groundglass can be measured with sharp-pointed dividers or a small ruler to make sure that the opposite sides are of exactly the same length.

Lighting.

The next step is the lighting. When two lamps are used, they should be placed at a distance from each side of the original equal to at least twice the width of the original. Thus, if the original is an 8x10 print,

placed vertically, each lamp should be at least 16 inches from the nearest edge of the print. Both lamps must be placed at the same distance and in similar positions, but on opposite sides of the print, and both must be of the same intensity.

It is much easier to get good lighting with four lamps, one opposite the terminus of each diagonal of the original. By lighting the four corners it is easier to get uniform illumination all over the print. One of the most frequent causes of failure in copying is the uneven illumination of the original material to be copied. Irregularities in lighting which show up in the final print are often overlooked at the time the original is photographed because of the usual high level of the illumination. It is better to judge the uniformity of illumination by examining the groundglass, or if none is used, observe the illuminated copy through a heavy blue or neutral viewing filter.

Focusing.

After illumination comes the focusing. This is usually combined with sizing, because each change of size necessitates a corresponding change in focus. The size is controlled by the distance between the original and the lens. The camera can be placed at any distance from the material to be copied, provided the distance between lens and original is greater than the focal length of the lens. Then if the bellows is long enough, you can focus the image upon the film. However, if the distance between the lens and the original is less than twice the focal length, the image will be larger than the original. Thus, most copying will be done with this distance equal to more than twice the focal length of the lens. Usually the reproduction is to be smaller than the original, but it is possible to obtain any image whose size bears a reasonable rela-

tionship to that of the original. In my laboratory I often have occasion to make photographs that are in a sense copies, but in which the image obtained is as much as 50 times as large as the original.

The size, then, is set by adjusting the distance between camera and original. This size must be verified after focusing, because the act of focusing can alter the size somewhat. You will find in this step a close parallel to sizing and focusing an enlarger. In fact the entire process of copying will be found to be, step by step, very similar to that of enlarging.

In focusing, there is no depth of field to be considered. Provided you use a corrected lens, this means that you will gain very little by stopping down; *f* 5.6 to *f* 8 is a good copying range, and compensates for slight inaccuracy in focusing. It is definitely wrong to use extremely small stops, because of the image diffusion caused by diffraction at the edge of the small aperture. The use of a moderately large aperture favors sharp focusing, as the image sharpens and falls off decisively, leaving little doubt as to the position of correct focus.

Making the Exposure.

With the original set and properly illuminated, the image brought to correct size and sharply focused, you are ready to make the exposure. This is the point where so many beginners fail, although it is the simplest problem imaginable. Consider a photographic original. You know that the tonal range can hardly exceed 60 to 1. This means that you can place practically every tone in the image on the straight-line part of the curve, and thus get faithful reproduction. You do not have to worry about extremes of highlight and shadow. You simply determine the correct exposure and give that exposure. The meter will serve to meas-

ure the exposure, and with an original 8 x 10 or larger it can be used in the normal manner. For a small original you can take a meter reading from a piece of neutral gray paper placed in the same position as the original.

The one tricky point in exposure determination is that of distinguishing between the **marked** and the true

Dist. from Lens to Subject (In focal lengths)	Diaphragm Factor Used to Obtain Effective f-Value	Extension Beyond Infinity Setting (In focal lengths), or Image Size Ratio	Exposure Increase (Based on exposure at infinity)
101	1.01	0.01	+2%
11	1.1	0.1	+20%
10	1.11	0.111	+24%
9	1.125	0.125	+26.5%
8	1.143	0.143	+30%
7	1.166	0.166	+36%
6	1.2	0.2	+44%
5	1.25	0.25	+62.5%
4	1.33	0.33	+77%
3	1.5	0.5	+125%
2	2.0	1.0	+300% or 4x
1.5	3.0	2.0	9x
1.33	4.0	3.0	16x
1.25	5.0	4.0	25x
1.20	6.0	5.0	36x
1.16	7.0	6.0	49x
1.143	8.0	7.0	64x
1.125	9.0	8.0	81x
1.11	10.0	9.0	100x
1.1	11.0	10.0	121x
1.0	Infinite	Infinite	Infinite

Fig. 121. Table of factors for calculating exposure increase and effective aperture for all lenses in closeup photography.

or **effective aperture.** The lens apertures are based upon the focal system, in which the diameter of the opening is expressed as a certain fractional part of the focal length of the lens. For example, a 4″ lens at *f* 8 has an effective diameter of ½″, because 4 divided by 8 equals ½. A series of relative apertures is usually

indicated upon the lens barrel or shutter casing for the convenience of the user of the lens. However, it is obvious that these values must always be incorrect except when the lens is set at one particular distance—usually its focal length for pictures at or near infinity.

In making photographs of the usual type, the amount of error encountered by focusing at various nearby points is negligible; but when we start working at such close distances as are used in copying, these errors become very large. In too many cases failure in copying results because the photographer did not remember that the aperture marked "*f* 8" on his lens was in reality "*f* 16," and thus forgetting that he gave only one-fourth the correct exposure. The several factors involved in copying, and their relative variations, are found in the table, Fig. 121. Intermediate values may be interpolated without too great difficulty.

In this table the first column shows distance between lens and subject expressed in focal lengths. Thus "2" in this column would indicate 4 inches in the case of a 2″ lens, or 10 inches in the case of a 5″ lens. The use of "focal length" units makes one table serve for all lenses. The second column shows the factor by which the marked diaphragm value must be multiplied to determine the true or effective aperture. Thus, if your lens is set at *f* 8 on the engraved scale and the object is 3 focal lengths from the lens, this factor is 1.5—indicating that the actual *f*-value is 12 instead of 8, as marked on the permanent scale. The third column gives the **additional** bellows extension beyond the normal infinity setting. This, too, is expressed in focal lengths. For example, if the subject is 25 inches from a 5″ lens (5 focal lengths), the extension is 0.25 beyond normal, or 1¼ inches, making a total extension of 5 + 1.25 or 6.25 inches. This same column also shows the **image size ratio.** The values indicate the size of the negative image as compared with the original. In

this connection remember that you can make a twice-size copy of a portion of an 8 x 10 original upon a $2\frac{1}{4}$ x $2\frac{1}{4}$ film! True, you will not get a complete image, but the **size ratio** will be there just the same. The last column indicates the exposure increase that is required to compensate for the added bellows extension. This column takes into consideration the alteration in *f*-values. Thus, if the meter indicates 1/100 second at *f* 8 and you are making a copy negative the full size of the original, you can refer either to the second column and use the factor "2.0" (this gives you a true *f*-value of 16, which then requires an exposure of 1/25 second); OR you can refer to the last column and, using the factor "+300% or 4x," increase the original 1/100 second exposure by four which will also result in 1/25 second. But do not make use of **both** factors, as this would result in the exposure's being reduced to 1/25 x 4 or approximately $\frac{1}{6}$ second.

For exact work, compensations must be made for all objects nearer than 101 focal lengths. This means anything nearer than 40 feet with a 5″ lens. However, for average photography no serious exposure error will be found for any object at a distance of more than 11 focal lengths from the lens.

As we have said before, copying is simply straight photography with attention given to the normal technical details which are encountered. Therefore, it will be obvious that the table of factors, Fig. 121, applies equally well to macrophotography and all other forms of closeup work.

Processing.

When the exposure has been determined, the film is exposed. The next series of steps involve processing. Here again normal procedure is followed—"normal," of course, means development adjusted to the emulsion

and subject matter. Although the emulsion choice comes first in practice, we will leave that for later discussion. It is not amiss, however, to say that ordinarily the emulsion chosen for copying is somewhat slow, fine-grained, and contrasty. It need not be panchromatic unless the original copy is in color. For black-and-white copying, ordinary positive or process emulsions are excellent (see Figs. 122, 123).

By using a finegrain, contrasty emulsion it is possible to make use of soft-working developers. In my laboratory most copying is done on 35 mm positive stock developed in DK-20, and there is no difficulty in obtaining full contrast. Of course in biblio work a more active developer is used. However, it is possible to copy a 3″ illustration from a good quality publication using a 133-inch screen, and from that 35 mm copy negative make a 11 x 14 print in which the actual half-tone dot structure is perfectly reproduced.

Fixing, washing, drying, and filing are quite conventional. Now that we have followed through with the primary factors, we shall consider the alteration of routine necessitated by special conditions.

Copying An Imperfect Original.

The original to be copied often is a photograph. The ideal is a black-and-white glossy print of good quality, but more often the original will have faults which interfere with copying. It may be on rough or textured paper; soiled or stained; tinted, toned, or otherwise colored; completely or partially faded. Usually the photograph submitted for copying is a loose print, or one that can easily be removed from its folder. In case a rough-surfaced print is glued to a solid mount, permission should be obtained to remount the original. The copying camera is supported vertically above the original, and the latter is immersed in

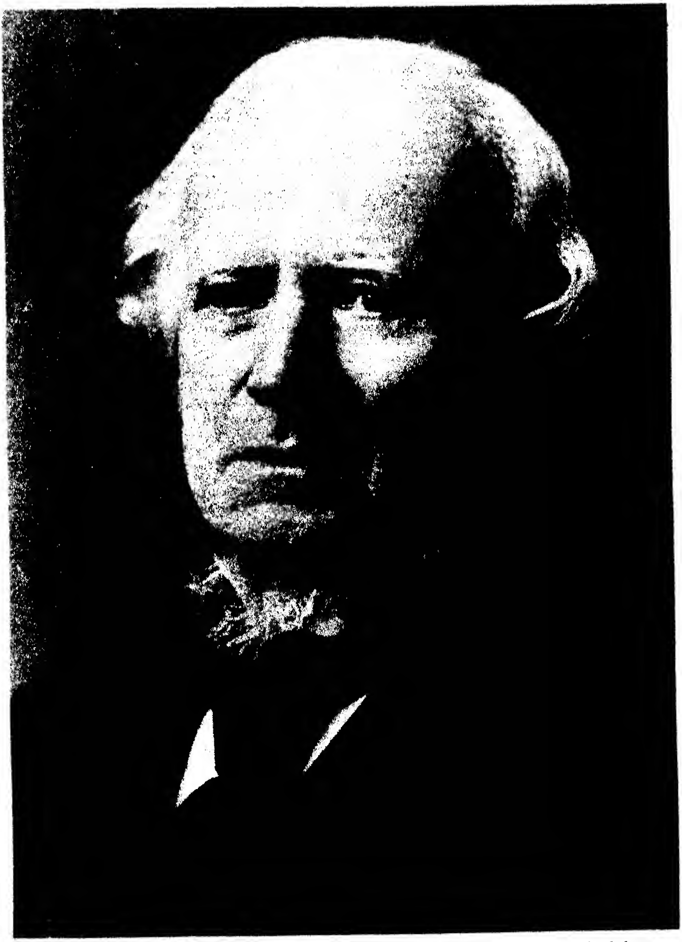

Fig. 122. Many old prints have a wealth of quality concealed by their faded tones. Here is a copy of one that was considered worthless, a straight print from the unretouched copy negative.

Fig. 123. Copy of a copy. Original 35 mm negative enlarged to 8x10; enlargement copied on $3\frac{1}{4}$x$4\frac{1}{4}$ film; contact print of negative copied on 35 mm film, enlarged to 5x7, and reproduced here.

a tray of clean water. The corners are held down by weights. Only a very thin layer need cover the surface of the print to remove effectually all traces of paper texture. Yes, the tray is placed under the camera, and the exposure made while the print is submerged. Obviously the pattern will reappear as soon as the print is removed from the water.

If the print has been fully hand-colored, about the only solution is the use of a panchromatic emulsion—process panchromatic in larger sizes and Microcopy or similar emulsion for 35 mm cameras. In the case of a tinted (stained) print, panchromatic film is used and a filter chosen which is nearest the color of the staining dye (this also applies to prints made on colored papers). For example, in copying the once popular blue-toned-pink-tinted prints, a red filter will effectually eliminate the pink and emphasize the blue image. To eliminate stains, or mass color, use a filter as nearly the color of the stain as possible.

In the case of toned prints, the reverse procedure is used. A filter is chosen which has a color complementary to that of the image. As a "faded" print is physically and chemically the same as a sulfide toned print, such originals may be classified as having been toned. For a blue tone, a red filter is used. This emphasizes the blue image. By the same reasoning it will be seen that a red filter will make possible the reproduction of a blueprint, which reproduction will be more legible than the original.

The browns, yellows, tans, and similar colors always seem to give the beginner great trouble in filter selection. In photography we ordinarily divide color into three groups—blue, green, and red. We know that green plus red makes yellow, so we have blue remaining. All these variations of brown will, upon close examination, resolve themselves into some kind of degraded orange, or a mixture of red and yellow.

Blue is conspicuous by its absence. Therefore, the use of a blue filter will cause all these tones to photograph as though they were much stronger colors. By the use of a blue filter, or by using a color-blind emulsion (which amounts to the same thing), the reproduction of a partially faded photograph can be so much better than the original that it is difficult if not impossible to detect the faded areas (see Figs. 122, 123). When prints fade they lose contrast, so in copying them it is necessary to build up contrast by using a slow, contrasty emulsion, and developing it for high contrast.

When old, soiled prints are to be copied, they should be cleaned. Unless you are positive as to the nature of the original, test your cleaning procedure on one corner of the print. First try an ordinary soft eraser, such as Artgum. If this does not do the work, try a mixture of alcohol and water. Grain alcohol is best, with denatured as a second choice. Do not use wood alcohol. Some old prints may not stand this treatment, so the corner test is advised.

Copying "Tintypes."

Among old originals will be those which are classed generically as "tintypes." Three distinct varieties will be encountered. The true daguerreotype is a fine-quality but delicate image of mercury on a silver or silvered copper base. The most common fault is a gray to bright blue stain. Two per cent potassium cyanide (one of the most deadly poisons readily available) will remove such stains. However, if the thin metal frame and glass are removed from the case, it will often be found that the only soiling is on the glass. Copy the original without the glass (Fig. 124).

The ambrotype is almost as common as the daguerreotype. When removed from the frame it will be found to be a bleached negative image on glass backed up by

Fig. 124. Copy of a daguerreotype. Considerable detail shows in this reproduction, but was barely visible in the original.

a black enamel which is usually chipped and cracked. Remove as much as possible and repaint with black lacquer or back up with black paper. These are usually unstained, and when freshened they often present less difficulty in copying than a daguerreotype (see Fig. 125).

The true tintype, or ferrotype, is a white-to-gray negative image upon a thin black-enamelled metal plate. Old tintypes often are scratched, dented, and broken, and usually present the greatest difficulty of all old originals. Clean the surface with ordinary mineral oil and wipe off with a very soft cloth before copying. The daguerreotype and ambrotype usually require additional contrast in the reproduction, but the tintype requires only normal contrast (see Figs. 126, 127).

When both continuous tone and line work are to be photographed on one negative, there is usually some little loss in quality. The reproduction of line work must have extremely high contrast, while that from a continuous-tone original, such as a photograph, must have contrast which would be normal in straight photography. For that reason it is always advisable, if possible, to make two copies on separate negatives and combine them later.

Tonal Range.

There is very little more to be said about copying as such, other than to discuss this matter of contrast of original and reproduction. True, there are many special phases of copy work, but these will be brought out in later parts of this chapter, since it will be found that many of the special processes in photography are founded upon copying technique. However, the problem of contrast lies in the fact that the tonal range of the original is usually far less than that of a normal subject. For example, it is not unusual to find outdoor

Fig. 125. Copy of an old ambrotype. Back of the original was freshly varnished before the reproduction was made. No retouching or spotting was done to either the copy negative or print.

subjects in which the highlight maximum is 500 times the intensity of the shadow minimum. Such a contrast range is equivalent to a density range of 2.7, and is not at all unusual. In considering the ranges found in originals to be copied, a full-range glossy print may be used as a standard. While the following figures were not obtained from a wide variety of measured originals, they are measurements made upon a limited series of typical originals. Moreover, in making the measurements, the zero point of reflection density was taken as the reflection of pure white photographic paper that was fresh and clean. Upon this basis let us consider some comparative density ranges:

Full-range glossy photographic print..	0.02 to 1.8	= 1.78
Daguerreotype	0.40 to 1.66	= 1.26
Tintype	0.74 to 2.0	= 1.26
Albumen print	0.2 to 1.2	= 1.00
Ambrotype	0.66 to 1.42	= 0.76

To make this more in line with general conceptions—that is, to avoid the logarithmic functions of the values—let us consider the approximate percentage equivalents of the above table.

Full-range glossy photographic print	95% to 1.5%	= 1:63
Daguerreotype	40% to 2%	= 1:20
Tintype	18% to 1%	= 1:9
Albumen print	63% to 6%	= 1:10
Ambrotype	22% to 4%	= 1:5.5
General outdoor subject........as much as 1:500 or more.		

Thus it will be seen that the tonal range of even the best original is far more compressed than the typical real-life subject. For this reason it is necessary to

work for greater than normal contrast. While the usual negative is developed to a gamma of 0.6 to 0.8, the copy negative will be developed to about gamma 1.0 or even somewhat higher. Assuming that the reproduction is to be made upon paper, the final over-all gamma should be such that the paper will just accommodate the full tonal range of the subject. By operating toward this goal, it is not difficult to obtain copy negatives of such nature that regardless of the original tonal range, the final reproduction will be of full scale.

This principle applies to all original copy—poorly printed originals (either continuous tone or line), colored originals, etc. It is obvious that if the image be sharply focused and the tone scale such that it fills the paper, the reproduction will be of satisfactory quality.

Bibliophotography.

This is a special phase of photography in which there are no continuous tones in the original. Instead it is made up of areas of specific density (usually lines) against a uniform background. Bibliophotography is concerned with the photographic reproduction of books and other material printed in type. **Documentary photography** is specifically the reproduction of documents, either printed or written. Neither of the two has any indication of image-to-subject size ratio. **Microfilming,** also called **microcopying,** is a type of microphotography that refers specifically to either biblio or documentary work in which the copy negative is considerably smaller than the original. Incidentally this term must not be confused with "photomicrography," which is the exact opposite. Photomicrography is the process of making photographs in which the negative image is considerably larger than the original subject. It will be noted that in microfilming a reduction greater than 1 to 30 is rarely used, and the term is not often applied

Fig. 126. Tintypes are the most difficult of all originals to copy. This reproduction made from one in very poor condition.

Fig. 127. The same tintype was cleaned, then given a coat of clear varnish and again copied. Note the general improvement.

to negatives of greater width than 35 mm. In its strictest meaning, the term "microphotography" is applied to the art of making photographs of such size that they can be seen only under high magnification. For example, in the slide library of my laboratory there are slides which portray the Milan Cathedral and the Blue Grotto. These pictures actually measure 1.1 x 1.4 millimeters. Another slide contains the entire Lord's Prayer in legible and perfectly formed type, yet the entire area is fully enclosed by a square which measures less than 0.2 millimeter on each side, or considerably less than 1/100 inch per side! This is the true microphotography. However, the use of 35 mm film has come into such widespread use for copying books and documents, and the practice of the original microphotography is limited to such an extremely small number of individuals, that the adoption of the word for the newer, practical photography has been unquestioned by many. The more limited terms "microfilming" and "microcopying" have been introduced and are found in current literature (see Fig. 128, 129).

The use of small film for making copy negatives brings into the technique no new or different steps, so we shall consider all three subdivisions under the general heading:

Making Copies of Line Originals.

The copying of line originals is often used as the starting point in learning to make copies. This is a mistake because, while the low contrast of continuous-tone originals provides for a wide leeway in exposure, the exposure for line work is almost as closely limited as is the exposure for color. The difference between ½ and 1 second often means the difference between a useless and a perfect line negative, although when ½ second is the correct exposure for a continuous-tone

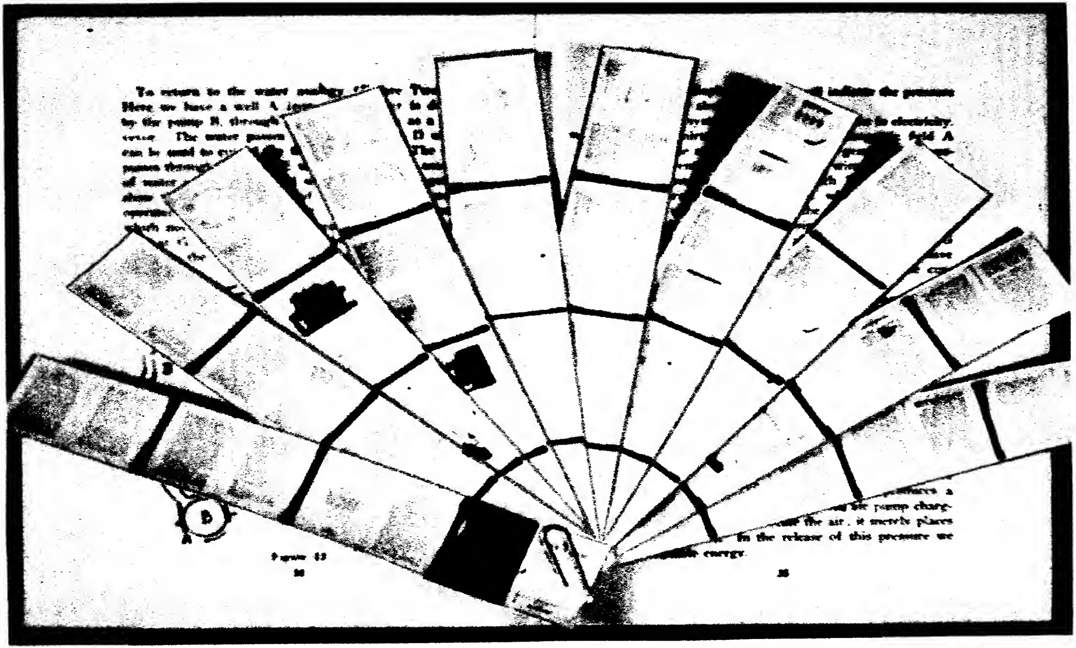

Fig. 128. Microcopy. The small strip prints laid out over the open book contain entire contents of this eighty-page volume. The copy negatives were made on a finegrain 35 mm film.

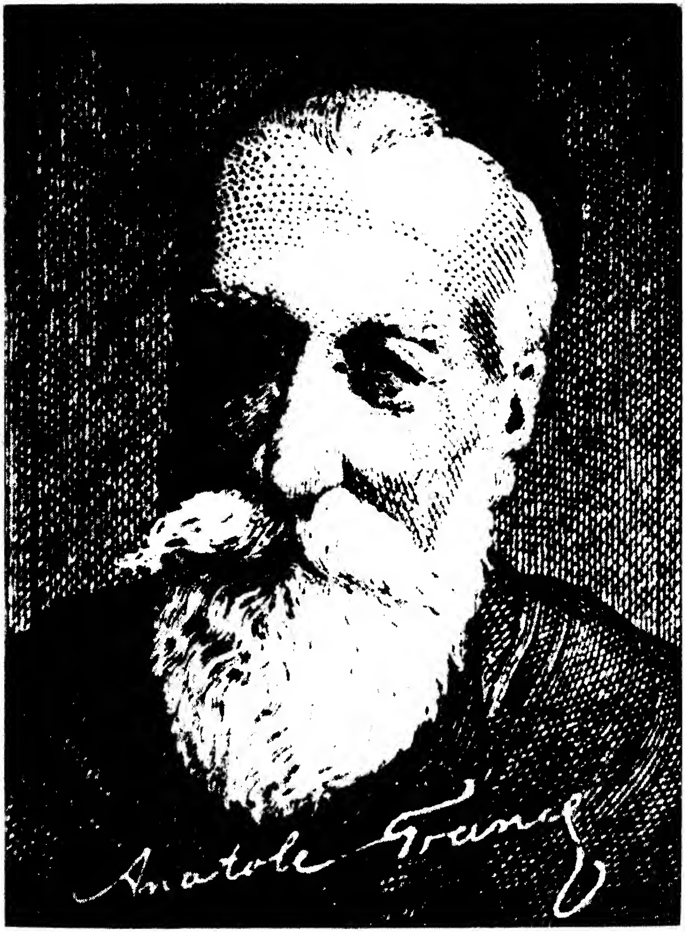

Fig. 129. This portrait of Anatole France was not taken from a woodcut. It is a microcopy—an enlargement of the main portion of a French postage stamp, blown up from a 35 mm copy negative.

original, a one-second exposure would produce a negative hardly distinguishable from the correct one.

The reason for this exactitude is difficult to understand at first. We have no tones to be reproduced, therefore why should the exposure be critical? In that respect the question is natural, and the answer is that there is no such critical point if only the stated factors are involved. However, in a line negative we want the lines to be as free from silver as the fog level will permit, and we want the background to be fully opaque. To give this opacity to the background, a long exposure is required. To keep the lines fully open, the exposure must not exceed the **limit of underexposure**—that point where the line begins to record. As this exposure is always less than could otherwise be given to get a solid background, the exposure is limited to that which is immediately below the one which would permit the lines barely to register upon the emulsion. Thus we have something not encountered in any other type of photography—a definite, hairline limitation. Admittedly this accuracy is theoretical, but we do make an effort actually to attain theoretical accuracy. There is no compromise center about which we can accommodate the under- and overexposure of various light intensities, but the one definite exposure which will give the best result.

To further the contrast, slow, hard-working emulsions are used, and hard-working contrast developers are required. There is one factor which must not be overlooked: when making copies on 35 mm panchromatic positive copying stock, it is possible to develop these in a contrast developer and still make perfectly legible enlargements up to 20 diameters. This would ordinarily be impossible, but as these emulsions are inherently fine-grained, this result will prove to you that a fine-grained emulsion is worth ten times as much as a finegrain developer (see Figs. 130, 131).

Fig. 130. Line copying requires critical exposure. An original with heavy black lines is easiest for the beginner to work with.

Inasmuch as we are working with lines, we should give some attention to the character of the line. This has to do with its absolute color, the relation of line color to background color, the definition of the line, and its outline. Incidentally, etchings are fundamen-

tally continuous-tone subjects and should be treated as such, rather than as line subjects. A line copy of an etching reduces all line values to the same point, hence such a reproduction rarely resembles the original. Etching lines vary in contour, edge character, and color (depth of tone). These differences are practically microscopic, yet they give to the etching its characteristic appearance, an appearance which cannot be duplicated by lines of uniform color and definite edge.

Line originals, especially those written or drawn with a pen, will often vary in depth of color. It is the aim of the reproduction to show all these lines as uniform and of full color. This means that the exposure limit is determined by that of the lightest-colored line. Therefore, as the line becomes lighter and lighter in color, the exposure must be made less and less. This gives us the key to pencil originals. Usually the beginner increases the exposure for pencil work in an attempt to register the faint line. This is an error. The pencil original is to be given less exposure than one in ink. When the original consists of a shaded pencil or crayon drawing, it is treated as a continuous-tone original, and if colors are used a panchromatic emulsion is required. Pen drawings, on the other hand, are copied as line originals, and if colors are used, the process panchromatic emulsion is used in the same way.

Use of Contrast Filters.

The most useful auxiliary equipment of the copyist is a full set of contrast filters. These are useful, not only in handling colored originals, but they are invaluable when dealing with colored paper. This may seem of little importance until it is remembered that practically all paper is colored; rarely indeed do we meet with a fresh, snow-white sheet of paper. Papers

faded with age, discolored, originally cream to India or tan in color, may all be improved in reproduction by the use of a yellow or orange filter. Red and brown papers, on the contrary, often respond better to an orange or a red filter. For this work it is useful to look at the original through the filter and see if this increases the contrast, although looking through a filter is not an exact check upon final results.

Filters are used to darken lines as well as to lighten backgrounds. In photographic examinations it is usual to ask what filter would be used to photograph a typewritten letter in which the typewriter ribbon was bright blue and in which corrections have been made in red and in green ink. We know that a tricolor blue filter would leave the corrections but tend to eliminate the writing. A green filter or a red one would darken the blue writing but would eliminate one set of corrections. Inasmuch as the answer must indicate some filter, a filterless shot cannot be accepted. The answer is a yellow corrective filter. This will suppress the blue sensitivity of the film, thus allowing a longer exposure for the red and green, and will darken the blue typing. Ordinarily, however, the filter chosen is the opposite color of the writing which is to be recorded, and similar to any alterations, corrections, or stains which are to be suppressed in the reproduction.

For example, a blueprint photographed on ordinary (color-blind) film is barely legible, because the blue is almost as strong as the white. If a pan emulsion is used with a red filter, the print from the copy negative will show the blue as black with the white lines unaffected, thus resulting in a reproduction actually more legible than the original. A student once tried this with a working drawing of reddish brown lines on white paper, and was bitterly disappointed when his reproduction proved a failure. When speaking of a "blueprint" we do not mean simply any working draw-

Fig. 131. This illustration was reproduced from a photographic copy of an old woodcut. It shows the equipment needed for making pictures outdoors by wet collodion process many years ago.

ing, but a print of white lines on a blue background, or vice versa (see Fig. 132).

When continuous-tone originals have been stained, careful technique is necessary to obliterate the stain from the reproduction; but in the case of line work this is easier. The filter is chosen which most nearly matches the color of the stain, and the exposure is made. The stain is usually light enough so as to be eliminated in the high contrast printing used for line work. However, the stain must be a true stain—that is, a transparent color such as made by red ink. An opaque color can be reproduced as a solid white or gray patch, but a heavy black as made by drawing ink will reproduce as such, and no filter application will remove it.

In the matter of sharpness, the same care is taken as with all copying, the definition being obtained through careful focusing and not by the use of an ultra-small aperture. No matter how small the aperture, the focus will not be crisp unless the lens is accurately focused. With a lens of ordinarily good quality, a sharp focus at *f* 8 will provide better definition than a slightly inaccurate focus at *f* 32, even disregarding the diffusion of refraction of the small aperture.

Other Aids to Obtaining High Contrast.

In both continuous-tone and line originals, it is quite easy to provide more contrast in the reproduction than was present in the original. In the case of a hopelessly flat original, a copy negative is shot and developed to the most extreme contrast possible. From this a positive is made on a glass plate, and this also brought to the fullest contrast. From this positive transparency another negative is made, and in all but the hopeless cases this final negative will be found to possess ample contrast. Usually it is possible to preserve a tonal re-

lationship which makes possible an ultimate reproduction on paper of full tonal range, even though the original was practically a monotone.

In line work particularly we often have to deal with thin paper. Although we usually consider paper as being "white," most of it is sufficiently transparent to affect reproduction. If the paper is blank on the reverse side, it is backed up with heavy white paper. This adds to the original contrast and makes the reproduction easier. However, if the paper has printing on the reverse side, it is backed with black paper. While this reduces the contrast, it also eliminates the printing on the reverse side, and by using a little extra care the contrast is built up to give a "clean" reproduction.

The procedure for obtaining high contrast, then, combines two steps: (a) the use of a slow, high-contrast emulsion, followed by (b) the use of a developer of the high-contrast type. This is a developer which often contains hydroquinone and no metol, and often employs sodium hydroxide for the alkali rather than sodium carbonate.

In developing the various emulsions used for copying, it is best to use the specific formulas recommended by the film manufacturer for the desired result. Process, panchromatic process, positive, and other emulsions used for copying are readily available, as are the 35 mm films made especially for microfilming. Several high-contrast formulas used with process and positive films are given in Chapter IV.

The photographer should strive to obtain the desired characteristics in the developed negative, however it is better to err on the side of overexposure than underexposure. The overexposed line negative will have a fully opaque background with the lines light to medium gray. This negative presents too little contrast for a good print. It can be subjected to reduction in Farmer's Reducer until the lines are completely free

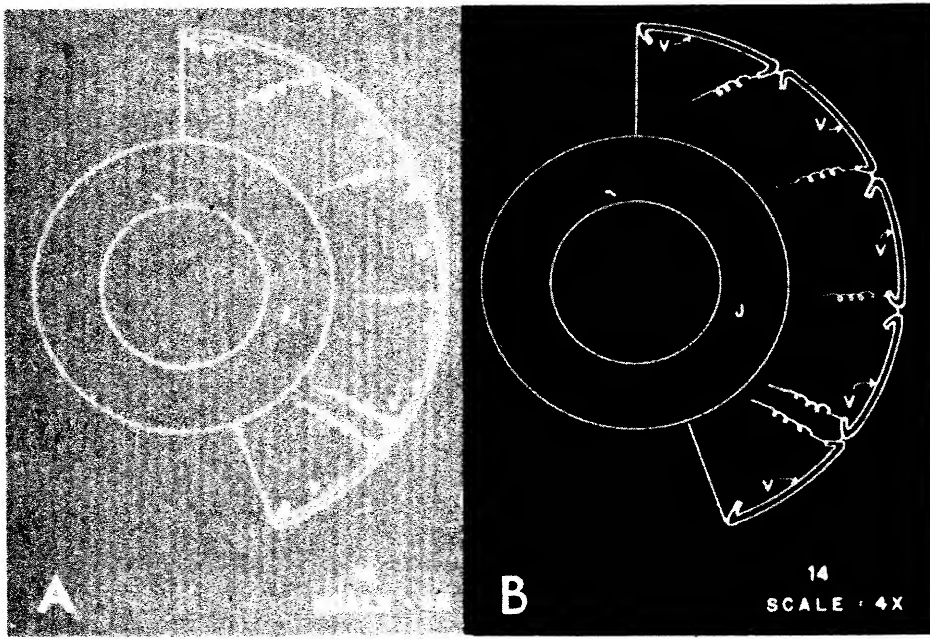

Fig. 132. A, blueprint copied on ordinary film with no filter; B, same blueprint copied on panchromatic film with a red filter.

from any silver. This is best determined by examination under moderately high magnification. When this has been brought about it is quite possible that the background will have been reduced sufficiently to render it too transparent, and although the lines are clear, even the least exposure necessary to darken them in the print will produce a faint background tone. When the negative has been well washed following reduction, it is intensified in some intensifier such as uranium. This will render the background fully opaque again. If every bit of silver has been removed from the lines they will not intensify, and as a result a perfectly clean line negative of high contrast is obtained. This combined reduction and intensification can also be used on ordinary continuous-tone negatives at times, but care must be exercised to combine the active solutions so that the desired result is obtained.

Scratched, Broken, and Damaged Negatives.

Fortunately, since the introduction of film base, we are not so badly troubled with broken negatives, but we do have all sorts of other accidents happen to them. We shall consider briefly the various injuries to which the negative is subject, and indicate what remedial measures, if any, can be applied.

Faded Negatives. Fading is usually caused by insufficient washing or fixing, or both. The "fading" is really sulfide toning, so that the best remedy is to wash the negative thoroughly, then deliberately tone it by sulfide redevelopment. To do this the negative is bleached in a solution containing 1 ounce each of potassium ferricyanide and potassium bromide in 20 ounces of water (30 grams each in 600 cc). If the negative is not washed and contains traces of hypo, this bleach will tend to eat the image away completely; therefore thorough washing must pre-

cede bleaching. When all the black part of the image has been turned into a tan to yellowish color, rinse it about two minutes in water, then place it in a solution made by dissolving 2 ounces of sodium sulfide in 5 ounces of water (60 grams in 150 cc). Note that this is **sulfide,** an evil-smelling bluish-gray lump material, and not the sulfite ordinarily used in developers. In this solution, reminiscent of outdated eggs, the image becomes brown, the exact color ranging from a deep mustard to a rich beaver brown. It is then washed for about 20 minutes and hung up to dry. The image will be found to be somewhat more contrasty than it was originally. It is quite stable in this form, but the negative should be kept in an individual envelope, and not packed next to other negatives.

Broken Negatives. When a glass negative has been broken, the pieces should be assembled, emulsion side up, on the glass of a printing frame or contact printer. They should be separated by about a quarter of an inch. When some pieces are missing, their places are simply left vacant. A print on smooth, luster paper is made from the fragments. When this is dry, the "pieces" are carefully cut out with a sharp knife or scissors. A mounting board of the proper size is covered with rubber cement, as are the backs of the various pieces. The pieces are then carefully fitted together in their respective places, the cut edges matched as closely as possible. Blank spaces are filled in with properly shaped pieces of the same paper, which has been fixed out without either exposure or development.

When all the pieces are assembled and rolled out flat with a heavy print roller, the crevices between the pieces, where any such occur, are filled in with a pigment, the base of which is white poster paint mixed with sufficient black to match the tone of the area where it is applied. The wet paint is allowed to pile up somewhat above the surface. If it does not dry

down to the surface level, the surplus is removed with a sharp etching knife. When the crevices have been filled, any scratches are filled in with color just as in ordinary print spotting. If there are undesirable telephone wires or similar defects in the print, these may be removed at this time. Blank spaces are filled in with flat color, and details built up to match the rest of the print. When the spotting is completed, a copy negative is made. When the negative is broken into a few large pieces, each fragment may be enlarged, thus providing a larger area upon which to work. This reduces the possibility of the remedial work's being detected.

Scratches, tears, blisters, and other defects upon film negatives may be handled in the same way, but in this case an enlargement should invariably be made. As a rule, a 10x12 enlargement is made from a 35 mm negative, while from 3¼ x 4¼ negatives a work print not less than 16 x 20 is advisable. When a negative has reticulated so that the subject cannot be printed, the use of a paper negative often will result in the reticulation's being masked to such an extent that the picture can be used. This, of course, depends upon the extent to which the reticulation has proceeded. Paper negatives will be discussed later.

Duplicate and Enlarged Negatives.

Differences in a photographic emulsion are, in the broader sense, those of degree and not of kind. You can use contact or enlarging paper in the camera, and by sufficient exposure obtain an image which develops as a negative. You can use any kind of negative material, plates or films, and by exposing them to the direct or projected image of a negative you will get a positive image. We call some materials "negative" materials and others "positive" materials simply be-

cause they are best fitted for those respective purposes —not to imply that their use is limited to them.

Therefore it is possible to make negatives by projecting a transparent positive image just as it is possible to make a positive by projecting a transparent negative image. Thus, when a large number of identical enlargements are to be made from a small negative, particularly when a considerable amount of hand work is to be done upon each print, an enlarged negative is made, the handwork done upon this, and prints made either by moderate scale projection or by contact. As a rule the steps are:

a. Enlarge the image, using a process or diapositive film or plate instead of enlarging paper. Process this in the usual manner.
b. Any portions of the image which are to be darkened are darkened by pencil or crayon upon this enlarged positive. A matte-surfaced film will be of help at this point.
c. A negative is made by printing this positive, by contact, upon a similar process or diapositive emulsion. Any parts of the image which are to be made lighter are darkened upon this negative by pencil or crayon.
d. Prints are made from the enlarged negative as desired.

Process emulsions are used for this work; be sure you get the slow, color-blind type. In making the enlarged positive you do not work for the same quality desired when making a transparency or lantern slide. The highlights are quite heavy, and the whole image in the tray appears quite black, just as an ordinary negative does under similar conditions. A good transparency, such as a lantern slide, is entirely too thin and delicate for the production of a good negative. Many if not most of the extreme highlight details are subdued or even lost. Therefore, remember to develop the posi-

tive to a heavy degree, but do not permit the shadows to become entirely blocked or opaque.

It will be obvious that the duplicate negative has a much shorter scale than the lantern slide, that it has a much softer gradation with its heavier highlights and grayer shadows. This is necessary because it must be kept to a range which can be printed upon paper, while the lantern slide may have a usable tonal range exceeding 1:1000. This is true of all duplicate negatives, including the paper variety.

The negative is made from the positive in the same way. In both steps try to obtain a density which is similar to that of a good negative. This will necessitate a short development and consequently a somewhat longer exposure than for a good transparency. It is by the coordination of exposure and development that you obtain the desired balance between density and contrast in this work.

If desired, and if no handwork is necessary, the positive can be made from the negative by contact, and the negative by enlarging this small positive; but as a rule it is advisable to enlarge the positive. In some cases where a very small negative is to be enlarged considerably, both steps are done by projection—for example, a 4 x 5 positive from a 35 mm negative, and a 16 x 20 negative from the 4 x 5 positive. This is sometimes altered to produce a 2¼ x 3¼ positive, then a 4 x 5 negative, and then 16 x 20 or larger prints from this negative. This last method has been resorted to so that grainless prints of large size can be obtained from a miniature negative. However, the enlarged negative is usually made if it is desired to introduce handwork when a number of identical enlargements are to be made.

Paper Negatives. One type of enlarged negative recently has become popular—almost too popular. This is the paper negative, which is nothing more nor

less than an ordinary enlargement whose image is negative rather than positive. It is either made upon very thin paper or upon regular paper which is then oiled to render it more transparent. This paper negative is used just as is any ordinary negative for making prints, usually by contact.

An idea is prevalent that the use of a paper negative must perforce result in an "artistic" print. Nothing could be further from the truth. Unless the photographer has a picture to start with, and unless he uses his medium to good advantage, the paper negative simply gives a smudgy, mottled print! This is no attack upon the paper negative as an expressive pictorial medium. In skilful hands it can be used for the production of exquisite pictures. There can be no doubt of that. But such a result comes from the skill of the worker in handling a difficult medium, and not as the inevitable result of using that medium. You might as well expect success in painting to come automatically through using some special brand of paints.

We have no intention of discussing the paper negative as a medium of artistic expression. This is a technical discussion. However, we will remark that while the paper grain pattern has occasionally been used to good advantage it is, on the whole, a disadvantage. However, for the photographer who desires to make use of the advantage of the paper negative, it is suggested that the special translucent, double-coated papers made under various names by the different manufacturers are ideal. Results are not grainless, but the grain is reduced to a texture rather than an irregular spatterwork. The material provides ample surface for handwork, and has much better printing characteristics than ordinary bromide paper, owing to its combined fast-slow emulsion coated on both sides of the paper.

When such translucent paper is used, the procedure is exactly the same as if a transparency were being

made, with the extra exposure necessary to provide the depth of full-range detail desirable in a negative. Highlights should have body instead of being transparent. Of course, in the negative image the actual highlight represents the shadow areas, but we are making a comparison with an ordinary transparency and so shall compare density with density.

Similar double-coated materials are available on a film base. This base may be transparent, translucent with a body similar to groundglass, or with a milk-white translucent base. The three varieties offer a material which permits a much wider application of "paper negatives" than will be found if the ordinary bromide paper is used as the medium. The best way to learn to make these negatives is to experiment. Try different exposure and development ranges, and make a print from each experiment. These experimental negatives and their prints should be filed. A convenient way to do this is to work with the 5 x 7 size, then perforate the edges of both negative and print and file them in a medium-size looseleaf book.

The true value of the "paper negative," of course, is the ease with which it will take handwork. The media described above as substitutes will take such handwork almost as readily as straight paper, and thus they offer a substitute which is superior to the original material. Among such media are:

Defender Adlux. Transparent film; double-coated; tonal capacity, 10 times that of a paper print.

Defender Duolux. Opal white base; one side matte, the other semi-matte; extended range due to transparency as in Adlux.

Eastman Translite. Double-coated, translucent paper; extended tonal range of transparency medium; recommended particularly for paper negative work.

Eastman Translite Film. Similar to above, but coated on film base rather than on paper.

The extended tonal range of the above media has already been explained. It is based upon the greater transmission of highlights, but particularly upon the fact that shadow transmission can be reduced to a fraction of a per cent, while reflected density of the blackest paper cannot be forced down to one per cent.

Other Types of Special Negatives.

Bas Relief. The photographic bas relief, which was popularized and then almost forgotten long before most of us were even born, is a simple but effective medium for certain subjects. The less detail there is in the negative the better. Portraits lend themselves exceptionally well to this manipulation.

The negative should be of the type which will make a good transparency, having a full range, yet without excessive harshness. A positive transparency is made by contact, and for this purpose a glass plate is used. It is even advisable that the negative itself be glass, but this is not absolutely essential. The positive image should be of about the same contrast as the negative. When the positive is dry and registered with the negative, tonal values should cancel out and leave the whole a more or less uniform gray. Of course, a suggestion of outline will be visible, but theoretically there should be almost complete cancellation.

The positive is slipped out of register in one direction. Although this direction is in one sense immaterial, the effect is improved if the slip is made diagonally. The amount of slip will determine the apparent degree of relief in the finished print, but it is unwise to have it exceed 1/16 inch. The positive is bound to the negative at the edges in this position, and the whole is then used as a normal negative for projection or contact printing.

The neutralized areas will print out gray, but the

lines of misregistration will print dark, and will thus resemble the shadows of a bas relief. Although a simple stunt, if handled properly with a suitable subject, excellent results can be expected. The procedure has a value exceeding that of novelty. In the case of an object of simple geometric outline, some aerial photographs, and some topographical subjects, the procedure actually makes details more emphatic than they are in a straight photographic print.

Liftouts. The liftout is a photographic copy in which the new negative is restricted to a portion of the original copy. The most common example is that of lifting out a single individual from a group photograph. This is done in several ways, some of which are easier than others. All, of course, usually depend upon making an enlarged reproduction of the original. Several methods are as follows:

a. The selected portion of the original is copied to enlarged scale. A high-ratio enlargement is made of this part of the original. The selected portion (head, for example) is isolated by handwork, an airbrush being a favorite isolation medium, and the worked-up print again copied.

b. The selected portion is isolated upon the original print, using a non-staining water color (lampblack and zinc white, for example), and then copied. The original is washed to remove the water color, carefully dried, and remounted if necessary.

c. A small vignette of appropriate size is torn from black paper, the edges roughed and turned up away from the surface of the print. It is held by small flecks of rubber cement. The copy is made with lens wide open to diffuse the turned-up edges. This provides a black vignette background.

d. This is the same as (c), but white paper is used. The plain white background is suitable for working up in the final print, just as the black background

provides opportunity for working up on the enlarged copy negative.

e. An enlarged copy is made, the selected portion cut out with a sharp knife or scissors, mounted upon a background, and re-copied. This is the simplest procedure, but never entirely satisfactory; the harsh edges look like just what they are—paper cutouts.

f. The copy negative is used to make a projection print in which the selected portion bears the desired size relation to the paper used. Surrounding detail is vignetted roughly as in ordinary vignetting. After fixing, a reducing solution, containing hypo, is used to blend the vignette closely. The reducer is applied by a brush or cotton swab, and the print washed at short intervals to prevent the reducer from flowing back into the wanted portion of the image (see Figs. 133, 134).

g. This method is similar to (f), except that the mask vignetting is done more carefully, using a vignette formed to the image; no further treatment is attempted. This is the simplest method which gives good results, but it requires careful and painstaking manipulation.

Composites in General. A wide variety of effects is obtained when two or more negatives are used to obtain a single print. There are so many types of composites that any attempt at classification must be open to many objections. However, as classification is essential to satisfactory description, we shall attempt it:

a. Synthetic composites. In these, various specific elements are taken from various negatives to build an apparently homogenous whole. Examples: adding clouds to a barren sky; placing the head of one person upon the body of another; adding a human figure to a miniature or tabletop scene.

b. Group composites. This is often referred to as a "montage." It is made up of several separate photographs assembled either with edges touching or slightly

separated into the conventional layout. The shapes may be regular or irregular.

c. **Montage.** The identifying characteristic of the montage is that the edge portions of one image blend with or overlap those of the adjoining one. In short, the edge portions are exposed to both adjoining images. A montage cannot be made by cutting and fitting separate pictures; it must be made by successive exposures upon one sheet of sensitive material, either in the camera or during projection.

d. **Selective composites.** This is used, for example, when two exposures have been made of a group. Figures at one side are unsatisfactory in one shot, those at the other in the second. The two good halves are joined to make a single composite with the good parts of each. A similar type of composite makes a panoramic view of several single shots, or is used to overcome distortion in outdoor views by combining views taken from nearby but not identical points.

e. **Line-tone composites.** This type combines line portions and continuous-tone portions in a single negative. A familiar example is the photographic greeting card. Each of these types will now be considered in detail. In each it is obvious that some handwork in the nature of retouching is required.

Many readers will wonder when the retouching will be done. Of course, those skilled in working upon the negative with both knife and pencil will be able to do so. But if the amateur is not skilled in retouching, to attempt it would in most cases mean the destruction of the negative. However, print retouching is comparatively simple, and a print lost only means a new print to be made. Therefore, except for the simpler applications of pencil and crayon sauce, we shall exclude actual negative retouching and substitute handwork on the print—a corrective measure which lies within the ability of practically any amateur.

Fig. 133. Head in circle was "lifted out" of this old montage. A copy negative was projected onto the easel, and the desired portion of the image vignetted; see method (f), on page 650.

Fig. 134. Copy of head "lifted" from montage, Fig. 133. No negative retouching or print spotting was done to remove the spots or silver stains; both could be employed to improve the picture.

Making Synthetic Composites.

In considering **synthetic composites,** suppose we start with the cloud negative. The straighter the horizon line in the scenic negative the better. However, an attractive picture rarely has an unbroken horizon; so we cannot make this a condition of procedure. We will have certain elements of the composition rising well into the upper portion of the picture. To meet this need we require a cloud negative in which the cloud forms do not come too close to the horizon. Moreover, the cloud negative should have a type of lighting which corresponds to that of the scene. When you make cloud negatives, make some from each cardinal and intermediate direction, or at such related times that a variety in lighting will be obtained. A scene lighted from the right with clouds lighted from the left is disturbing to everyone, whether he is observant enough to locate the trouble or not. But remember that a cloud negative can be reversed in enlarging, and the direction of lighting reversed, too.

The negative for the scene is projected upon the easel. When it is located as desired and sharply focused, a cardboard is laid over the image and raised about an inch from the easel surface. A pencil line is drawn along the line which divides the objects of the picture from the sky. Trees, towers, hills—all are followed. The mask is then cut along this line. The cut edges of the mask are frayed with a needle, and you are ready to proceed. The paper is exposed with the top portion of the mask held slightly above the easel to protect the sky area. At the end of the exposure the red filter is swung over the lens, and the lower half of the mask is put into position so that it just covers the scene, but raised about an inch from the paper surface. The negative is then removed and the cloud negative inserted. It is positioned to give the formation desired,

the red filter is swung aside, and the cloud exposure is made.

When carefully followed, this method gives excellent results, but a slight misjudgment of the mask positions will produce either a dark or a light line around the foreground objects. It is advisable to make your cloud negatives with a red filter, using a comparatively long exposure. This gives a partially transparent background which produces a distinct sky tone. However, until you become adept it is easier to use a yellow filter to obtain a sky negative which is opaque enough that an "override" into the picture area is not so noticeable. Some pictorialists prefer to limit the clouds to the open sky and blend the two exposures by conventional dodging. The result is rarely convincing. However, by making use of the steps already explained in this chapter, the enlarged positive and paper negative method gives you ample opportunity to work out any slight slips in this double printing.

The example just given involves two exposures, one from each of two negatives upon a single sheet of paper. Now suppose we go a bit further and add a specific unit to a complete photograph. We might add an individual to a group, foreground figure to a scene, hang a bunch of bananas upon a maple tree, or what not. One of the most common examples is the interchange of heads and bodies, and the adding of a figure to a street or other background. Maybe you wondered when your friend Smith was in India. You know he was, because you saw a picture of him standing before the Taj Mahal! Such tricks are quite easy in composites.

Suppose you have a photograph of a woman dressed in full court robes. You also have a photograph of a woman whom you know quite well. You decide to make an interchange to see how your friend would look in the elaborate costume. The first step is

to copy your portrait if it proves suitable. Naturally the position of the head must match that of the body, and the lighting must correspond. If these conditions are met, the portrait is copied and a positive print made in which the head is exactly the size of the head in the costume photograph.

Now comes the real test of your skill. Edge lines are hidden by having them coincide with junction lines of tones, but when you must break an even tone area, the line is very difficult to hide; but we shall discuss this in a moment. The head is cut from the copy portrait and very carefully trimmed to its exact edges. The cut around the hair is not made too closely, however, and the neck line should extend down well below the shoulder line. This head is then placed over the head in the costume picture and carefully adjusted until it appears somewhat natural. Holding it here, draw two lines from the shoulder lines of the original down over the neckline of your head in the position a necklace would ordinarily occupy. If the costumed figure wears any neck jewelry, the top of such an ornament is the natural dividing line. If there is none, you will use this line anyway. When your substitute head is in place, carefully draw in a necklace, using spotting ink and a fine brush. This break hides the junction line.

When the neck junction line has been determined, you have to feather the edge of your substitute head. Turn it face down, and with a manicure board (fine side) file away the paper edge at an angle of not more than 10 degrees. This is continued until there is a tiny band of translucent emulsion showing all around the cutout. The feathered head cutout is now given a thin coating of some cement, as is the corresponding spot in the original. When both are tacky, the head is put into place, and the edges worked down with a bone or celluloid burnisher until they no longer incline to curl up. After an hour or so, any slight defects are covered

by careful spotting. When this type of pasteup is well done, it is difficult to see the substitution. But after the work has been done a copy is made, and unless some obvious error can be noticed in the original, there is nothing in the reproduction to indicate that the picture has been altered. This type of substitution is used in making many stunt photographs, including some surrealistic effects, which seem to puzzle those who see the reproductions. Of course, the degree of success to be expected from this procedure is dependent on the care taken in cutting, pasting, spotting, and retouching the altered picture, and in making the copy negative.

Making Group Composites.

A **group composite** is simply a layout of several photographs closely related. A set of photographs showing various phases of a single incident or subject are laid out upon a large sheet of paper. They are trimmed, rearranged, and interchanged until the arrangement is satisfactory, then cemented onto a mount in corresponding positions. They can be covered with a multi-opening mat, or each picture can be outlined with a black or gray line or band. Any similar decoration that is appropriate can be used at the discretion of the maker.

Another method in which the various elements are kept in a much closer relationship is that which is mistakenly called a "montage." In this type of composite, the various pictures are cut to odd shapes which will fit a preconceived pattern not unlike a simple jig-saw pattern. There are special masks on the market which usually have an oval central portion with radiating sectors surrounding it. Each is covered with a removable mask so that each space can be exposed from a different negative; this procedure eliminates the tedious cut-and-paste step.

Making a Montage.

The **montage** is a single photograph in which images from several negatives are blended to make one print. It resembles the second type of group composite to some degree, but it is characterized by the fact that the edges of all units overlap. Each unit is exposed through an appropriately shaped mask which is raised and lowered, during the exposure, so that the edges of the shape will be lighter than the central area by about 50 per cent. Each unit area in turn is exposed the same way. When the picture is developed, image elements at the edge of each shape will fade into the adjacent unit area. This work demands such care in balancing each subsequent exposure that once the effect has been achieved, a copy negative is made and reproductions from this negative are used instead of making a direct projection montage for each print desired.

Making a Selective Composite.

The **selective composite** hardly needs explanation. It is quite similar to the synthetic composite except that instead of a small area's being inserted into the original, two originals are cut apart upon some common line and then joined to make a whole. For example, tripod heads are available which automatically divide the horizon into a number of equal divisions, each of which can be photographed at one exposure. Thus by making the necessary number of exposures, the entire horizon can be photographed. If these photographs are joined together carefully, a full 360-degree panorama can be made which is free from the objectionable curvature found in pictures from the swinging type of panorama camera.

It will be found that near the edges of the pictures the same objects will be repeated on both sides of each

common division. This means that the pictures all overlap at the edges. When making the prints they are carefully kept to the same general tone, and all enlarged to the same scale. When dry, each print is carefully cut along the edge of some object which also appears in the adjoining print. Instead of feathering, the adjoining print is also cut along this line. The sections are joined, and the joints filled as described in the directions for restoring a broken negative.

In making a photograph of some particular section of a street, a succession of three or four photographs made at intervals of about 50 feet and then joined will give better perspective than will the use of a wide-angle lens. As in other cases, the handworked print is copied, and reproductions from the copy negative are the ones actually used. It may be said that this use of a copy negative is not only to avoid a repetition of tedious handwork—any handwork is visible to an expert—but the process of copying reduces all subtle color tones of paint and ink to the common photographic gray. Roughness of surface, which reveals handwork under oblique reflected light, is eliminated. In short, handwork in the original, which is plainly visible to almost anyone, becomes invisible even to the expert in the reproduction. In this connection it might be said that a great many photographs used for reproduction in publications are "doctored" by handwork before the engravings are made.

Making a Line-tone Composite.

The **line-tone composite** is the type of negative used for greeting cards. The usual method is to make up a large original with the enlarged photograph pasted to the line work. Then a single copy negative of the whole thing is made. As a result the line portion is so gray that it does not print satisfactorily, and the photo-

graphic portion is too clogged to be at all satisfactory.

These negatives should be made in two parts. The original for the line portion (decorations, message, and so forth) is made up with a sheet of plain black paper inserted where the photograph is to be. This is copied on a process emulsion and developed in a high-contrast developer. If necessary it is first reduced and then intensified to produce solid white lines on a fully opaque background. A copy negative of the photograph is made, carefully sizing the negative so that the picture will fit the line negative opening. When both are dry, the transparent space in the line negative is cut out carefully, and the picture negative cut to fit this space exactly. After inserting the picture negative, the edges are covered with a ⅛" band of black cellophane tape. In this case, of course, it is essential that these 1/16" edges of both negatives be free from important picture or type matter, so the band will not obliterate a necessary part of the original.

It is also possible to use stripping film for both negatives, cut them while wet, and fix both in their correct relative positions upon a glass base as is done in photoengraving. The first method is simpler for those who have never made use of stripping film.

Titling Negatives.

A similar process is used for titling negatives so that the title will print through on each print. The titles for any desired number of prints are written, printed, or typed on white paper—a group sufficient to fill a negative and copied at one time. When dry, these titles are cut apart and each one added to its appropriate negative. These title strips can be inserted as in the case of the greeting card. This will give a narrow white border around each title. Unless the picture negative is clear (heavy shadow) where the title

is to be applied, the emulsion should be removed with an etching knife. This will then leave a white border enclosing a white background bearing black letters. If a transparent positive is made from the title negative before cutting apart, and used in place of the first negative, the white border will surround a black background bearing white letters in the final prints.

Rubber type is available in a "reversed" face for the purpose of stamping titles upon negatives. However, as the ink rarely adheres uniformly this is not often advisable. Perhaps the best method for titling negatives is by the use of special negative ink which flows freely upon the negative (either surface) and is a permanent, opaque black.

Reversal Methods.

The use of reversal is the basis for many special techniques, and as it is quite simple, only brief directions need be given. Reversal is in reality the complete photographic processing procedure of negative development and positive printing all carried out in the same emulsion. The emulsion is exposed and the negative image developed in the normal manner. However, instead of fixing after development, the film is placed in a bleaching bath which removes the negative image without disturbing the sensitive emulsion remaining. In this step we have the exact opposite of fixing. After bleaching, the remaining sensitive material is exposed to light and developed. Obviously as this remainder represents a uniform original from which a negative image has been removed, it will be a positive. This procedure is that generally used in making direct color photographs with mosaic screen media such as in the Lumiere, Dufaycolor, and similar additive processes (see Fig. 60, Chapter V).

The method is widely used by amateur cine enthu-

siasts who use inexpensive positive film in their cameras, then process by reversal and thus obtain their finished films at a fraction of the cost of conventional film. Hundreds of cine amateurs have been highly successful in home reversal of movie film. Details have already been given.

Solarization.

If a film is given a tremendous overexposure, the image may be partially or wholly positive when developed. Reversal which is produced by exposing the film to white light before development is complete is called **solarization.** Note that this is caused by an exposure at some time **before** development is complete—that is, it may take place before making an exposure for the subject, or it may take place after development has progressed for some time. One interesting sidelight is that of giving a film a predetermined and comparatively excessive exposure to white light before exposure in the camera. The camera exposure then results in a positive image by direct development. If you want to experiment you will probably spoil several dozen films before you hit the exact balance between pre-exposure, camera exposure, and development.

Solarization has been the basis of some spectacular pictorial work. A subject is posed before a dead black background and the exposure made. This negative is developed in the usual manner. When the image of the model has had time to develop to a good density, but not quite fully, the developing negative is exposed briefly to white light. The sensitive emulsion of the dark background, which has remained inert up to this time, now develops rapidly. But as most of the available emulsion in the figure has been used, and as the developed image protects somewhat the under-

lying unexposed emulsion, the figure does not change very much. The result is that in the print the background becomes white instead of black. The same effect might be obtained by using a white background in the first place, except for one factor. The background immediately adjacent to the figure does not enter into the reversal, so that the figure is outlined by a fine black border which blends delicately into the white background.

In this type of work remember that objects which are white or light-colored will remain as they are (positive in the final print), while dark objects will be reversed in direct proportion to their degree of blackness. Solarization has been widely used for novelty effects, but only a limited number of subjects lend themselves to the process.

Hypersensitization.

A very brief exposure to white light has been recommended for hypersensitizing films. The idea is to overcome the inertia point of the film, so that any light impulse, no matter how slight, will be recorded. In this same connection we may mention hypersensitization by mercury fumes. This may be tried by shutting up a roll of film in a closed container with a few drops of liquid mercury. The best way to use this latter method is to wind the film on a developing reel, place the mercury in the tank, enclose the reel of film, and close the tank for about 48 hours.

Both of these methods of hypersensitization will work. Unfortunately, both tend toward increasing the fog level. As this is already so high in modern emulsions that reduction is often an important step in processing, any increase becomes really serious. Another factor is that our most highly sensitive emulsions seem to react to such treatment far less readily than the

slower emulsions. Therefore, if we want a highly sensitive film, we should obtain a conventional high-speed film and leave hypersensitization to the realm of interesting experiments. It definitely cannot be recommended as anything but an emergency measure, and while hypersensitization does not inevitably produce loss of quality, it is rare indeed that satisfactory quality is obtained from a film which has been either pre-fogged or mercury-fumed.

Infrared Photography.

Photography by infrared has for some reason captured the imagination of the public. The mere fact that a photograph can be taken where there is no light seems impossible—the curious fact, always overlooked, is that since the origin of photography we have been fighting for the ability to make photographs by visible light alone, and to exclude the unwanted action of invisible light. Of course, this particular invisible light referred to is the ultraviolet, but it is just as mysterious as the infrared.

We have used the term "invisible light." This is incorrect; "light" is a name for the effect which is produced in our brains through the medium of our eyes, by the stimulus of certain frequencies of the electromagnetic radiation spectrum. If we can't see it, it isn't light. "Invisible radiation" is a far more correct term. This distinction is important simply because radiation which is visible to some people is invisible to others. There are well-authenticated cases in which vision extends as far as 350 into the ultraviolet and almost to 800 in the infrared. Therefore, the limitations of ultraviolet and infrared are definitely individual limitations.

Another factor which should be straightened out: "Ultra" and "infra" are not adjectives. Infrared is

definitely not a specific kind of red. It isn't red at all. Red is a name given to a visual sensation, so infrared cannot be red. The name simply indicates that this is a radiation **below** red, just as ultraviolet isn't a shade of violet, but is simply the radiation **above** violet. A series of black objects—paper, wood, metal, cloth, and so forth—when photographed by infrared show tones ranging from white to black, indicating that in objects which we call "black" there is a play of infrared differentiation entirely analogous to our color spectrum. In the ultraviolet, fluorescence changes with the wavelength, so here, too, we have a range of what might loosely be called "invisible color." In fact some small ultraviolet spectroscopes depend upon this fluorescent color change for calibration.

Neither ultraviolet nor infrared photography is mysterious, nor are they abnormal in any respect. Therefore, let us approach this discussion in a rational manner. Infrared film has the same blue-sensitivity which is found in most ordinary emulsions. Exposed without a filter, it will give a result quite similar to the old-fashioned "N.C." Kodak film. However, it has no sensitivity to green at all. It is sensitive to some degree to the lower visible red, but its greatest red-sensitivity lies in those wavelengths which are invisible.

Choice of Emulsion and Filter.

It should be understood that there are many varieties of infrared emulsion, with their greatest sensitivities at various wavelengths—just as we have colorblind, ortho, and pan emulsions for the visible radiation. Thus using the Eastman designation we have the selection shown on the next page.

Emulsions L and N are continuously sensitive throughout the visible region, and are not green-blind

Emulsion.	Full range.	Peak range.
Z	725-1200	1000-1200
Q	725-1025	930-1025
M	725-1000	860-1000
P	725- 925	825- 920
L	250- 900	No peak
R	725- 875	725- 850
K	675- 810	730- 790
N	250- 860	680- 860
U	650- 760	680- 745

as is usually the rule with infrared emulsions. It must also be understood that all the above emulsions are sensitive from 250 to 500, or from the ultraviolet down to the dividing line between blue and green. It follows, therefore, that if an infrared photograph is to be made, a filter must be used which will eliminate the blue and blue-green. The deep orange-yellow (Wratten G) filter is satisfactory, but most photographers prefer to use the tricolor red filter. It does not eliminate the visible red, but this is not objectionable in most infrared photography. Of course, in some scientific work it is necessary to have complete absorption of the visible red. This can be done by the use of a very dark filter, or by the use of the tricolor red with an emulsion such as the Z, Q, M, and P. These, too, are slightly sensitive to the visible red, but not to the degree of the L, K, N or U emulsions.

For the best effects, when the exposure is not a factor, use the R or P emulsion with a so-called "black" filter. This increases the exposure from 2 to 4 times as compared with that required when the tricolor red is used. There are no filter factors as we commonly know them. Some kind of filter is essential. The factors among the various filters have little reference to their visual density, but are simply comparisons of their transmissions in the infrared. Neither do we have any really accurate standard of exposure,

but it is usually accepted that the modern infrared roll film, which resembles the type R emulsion, will require from 1/25 to 1/100 second at *f* 4.5 with a tricolor red filter. The variation depends upon the amount of infrared available, and this depends upon the sun. The exposures given are for bright summer days.

You cannot make infrared photographs without infrared radiation any more than you can make ordinary photographs without light. The wild stories we hear about infrared photographs being made as snapshots at night are purely figments of the imagination of a writer who was not in possession of all the facts. The only way night photographs can be made by infrared is to have a source of infrared such as an incandescent bulb or flashbulb. To make the photograph in darkness, one only needs to have the source enclosed in a light-tight box with one side covered by an opaque but infrared-transmitting filter. This is now done by coating flashbulbs with an infrared filter enamel.

Many lenses are not corrected for infrared, and to get a sharp image it is necessary to extend the lens slightly. The amount of the extension depends upon the construction of the lens and its corrections. For most modern lenses the recommendations are for an extension of from ½ to 3 per cent; perhaps 2 per cent would be a good average. This means a 2″ lens is extended 4/100 or 1/25 of an inch (about 1 millimeter).

Uses of Infrared.

Bearing in mind the advisability of using a correcting extension to get sharp focus and the necessity for a filter, the routine of infrared will be found quite similar to ordinary photography. There are no particular points to be observed other than these two, and anyone familiar with ordinary photography can use infrared with full expectation of satisfaction.

The uses of infrared are many, but not nearly as numerous as we have been led to believe. You cannot make infrared photographs in the dark unless you have some powerful source of infrared available. Infrared will not penetrate dense fogs, as was claimed when the infrared camera was proposed to guide ships safely through fogs. Water and water vapor are among the best insulators against infrared. You cannot make photographs through every type of opaque paint or similar material; this is limited to certain inks and dyes which are infrared-transparent, just as you can photograph "through" a red ink stain with a pan emulsion and a red filter. In short, you cannot perform miracles with infrared; you can only take advantage of its wavelength.

Atmospheric haze (not smoke, dust, or fog) is caused by the repeated deflection of the short waves of visible light, i.e., the violet and blue rays. This is the reason for haze having a blue color. The blue of the sky is nothing but haze, and is caused in exactly the same way. Longer wavelengths (infrared waves) are not so easily deflected and travel along with little deviation from their paths. Therefore, a photograph made by infrared will show little or no signs of haze. This permits the photography of objects at great distances, such as mountain ranges, and makes the medium highly satisfactory for aerial photography at extreme heights.

Infrared does not reflect from painted surfaces with any uniformity at all. Foliage on living plants photographs as almost pure white, while an identical shade of green paint would probably be reproduced as a dark gray or black. Thus, infrared photography will penetrate camouflage which is perfect as far as visual observation is concerned. These two properties make infrared an ideal medium for military aerial photography.

The long waves of infrared have a greater power of penetration than do the shorter waves of visible radiation. Thus clinical photographs by infrared will show local inflammations before they show through the skin surface, and will often make possible quite complete photographs of the superficial blood vessels. Closely shaven beards show up plainly by infrared. In short, infrared photography gives us clinical photographs which make the skin appear to be a semi-transparent sheath instead of a practically opaque covering as seen by visual light.

This same penetration makes it possible to prove cases of overpainting in oil paintings. It makes possible the deciphering of printed material which has been blotted out with ink. But in both these cases it must be remembered that it will work only if the particular pigments or inks concerned are transparent to infrared. There are many cases of failure on just this account. If a printed passage is blotted out in the same kind of ink used to print the original, infrared will not differentiate them.

Infrared is also used in photomicrography, particularly to penetrate the hard shells of insects and similar organisms. In fact, the practical application of infrared is being extended every day. All photographers should have a working knowledge of the great advantages to be found in the use of infrared, but if you expect it to perform miracles or stunts in black magic you will be disappointed.

An entire volume could be devoted to special methods in photography—in fact many volumes could be used thus to considerable advantage. However, the examples we have given are sufficient to indicate that special methods are largely only applications of fundamental laws in ways which are slightly, but only slightly, different from normal. Therefore, we repeat a statement made earlier in this section, namely, that

special methods are, after all, only normal methods in photography.

For every problem which arises there is a special method which will solve it. If you will only base your first factors upon the fundamental concepts of photography you will have no trouble at all in constructing the necessary special method, and you will be able to do this as rapidly as problems arise. For every question there is inevitably a correct answer.

XI

DARKROOM CHEMISTRY

XI.

Darkroom Chemistry

Developing Agents.

THERE are dozens of different developing agents which have been used from time to time during the growth of photography. Of this multitude only a comparatively few have received sufficient favor to be regarded as "standard" developing agents. Those which have been recognized have certain desirable characteristics, and in some instances it has been found advantageous to combine two or more in a single solution in order to make use of their combined properties. The popular M-Q formulas are of this type. The photographer who is familiar with the properties of the several more common developing agents will be able to make intelligent use of these chemicals, particularly when special problems arise.

Practically all the developing agents are organic compounds. This does not mean, as often supposed, that they are of animal or vegetable origin, but rather

that they are compounds containing carbon. Most of them are produced in the laboratory from simple materials. Since 1851, the year in which pyrogallol was first introduced, well over two hundred distinct organic compounds have been used as photographic developers. Many of them served for purely experimental purposes, but there is a surprising number of compounds which are more or less widely used.

While we have no intention of giving a course in organic chemistry, certain facts which are not difficult to understand can be used to make the names of the developers significant instead of a meaningless jumble of syllables. One of the simplest branches of organic chemistry is that devoted to the **benzene compounds** (not to be confused with benzine, a fluid used for cleaning and as a motor fuel). In this group of compounds benzene is the fundamental unit from which a number of aromatic hydrocarbons can be formed, as we will see. The chemical formula for benzene is C_6H_6, but this gives us no clear picture of the molecule. It is important to know the structure, as there are several different derivatives of benzene which could have the same formula. Therefore, let us arrange the 6 carbon atoms in the form of a hexagon to show a definite spatial relationship, and to each we will attach one atom of hydrogen. Figure 135 shows the arrangement of the carbon atoms within the hexagon, and the hydrogen atoms attached at the angles of the figure. Notice that the angles are numbered in clockwise order, the purpose of which will soon become apparent.

The Benzene Ring.

Inasmuch as the hexagon which we have constructed is made up of 6 carbon atoms, it is not necessary to include the 6 C's every time the formula is written (Fig. 136). For the same reason we can omit

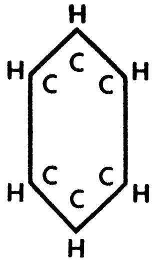

Fig. 135
Arrangement of C and H atoms in benzene molecule.

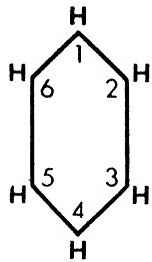

Fig. 136
Angles of the hexagon are numbered from 1 to 6, clockwise order.

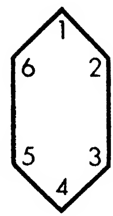

Fig. 137
H and C symbols need not be included when writing the formula.

the hydrogen symbols (Fig. 137), and lastly the numerals (Fig. 138), for the hexagon always has angle No. 1 at the top position. The resultant hexagonal symbol has been accepted by chemists as the formula-symbol for benzene, and is known as the **benzene ring.**

Various organic compounds are produced by removing one or more of the hydrogen atoms from benzene and substituting a different atom (or radical). Numbers are used to indicate the atom which has been replaced, although when no indication is given the number 1 position is assumed. When both 1 and 2 are substituted, the compound is said to be an **ortho** compound. When 1 and 3 are substituted, we have a **meta** compound, while if 1 and 4 are substituted the substance is said to be a **para** compound (**para**phenylenediamine, for example). Ordinarily the letters *o*, *m*, and *p* are used as abbreviations (*p*-phenylenediamine).

More than one such benzene ring may enter into the compound. These rings may be joined by their No. 1 angles, there may be an intermediate atom or radical between them, or we may have the junction in which two rings have one side in common. In this case

the numbers run from 1 to 8, as shown in Fig. 155, because two of the carbon atoms are common to both rings and form the bond between them.

Following is a list of atoms, radicals, and compounds that replace one or more of the hydrogen atoms of benzene to form the organic compounds used as developing agents:

OH—This is the *hydroxy* (hydroxyl) radical or group. With an atom of hydrogen it becomes water. By the addition of metals such as sodium or potassium it becomes a caustic alkali.

NH_2—This is the amino (amido) radical. It belongs to the family of ammonia (NH_3); but do not make the mistake of thinking of it as ordinary ammonia. However, the occurrence of the term "amino" (or amido) in a chemical name indicates the presence of this radical in the molecule.

CH_3—This is the methyl radical. This term is perhaps most familiar to us as descriptive of alcohol. Methyl alcohol (wood alcohol, methylated spirit) is a combination of CH_3 and OH, the formula being CH_3OH.

Cl—This is the halogen chlorine which is widely used in photography in preparing silver chloride, the sensitive basis of chloride papers.

Br—Bromine, a halogen similar to chlorine in its photographic applications, used for preparing the silver bromide of bromide emulsions.

HSO_3—A sulfur compound having, for our purposes, the name sulfonic acid.

H_2SO_4—The formula for ordinary sulfuric acid.

CH_2COOH—This carboxymethyl radical, as it is called, is acetic acid minus one hydrogen. Acetic acid is CH_3COOH or more properly $CH_3{\cdot}CO{\cdot}OH$; in other words, a triple combination of

methyl plus carbonyl (CO) plus hydroxyl (OH). So we have the name carbonyl-hydroxyl-methyl or "carb-oxy-methyl."

NH—This is the amino radical minus one hydrogen, which is replaced by some other atom (or radical). Thus, one hydrogen may be replaced by methyl, giving $NH\text{-}CH_3$.

Now we have the elements which will enable us to pry into the mechanism of developer formation. Starting with the original benzene ring and making substitutions, we can produce a variety of compounds. You will note in each case how the correct chemical name could almost be made up without knowing what the substance really is. Conversely, note how the chemical name accurately describes the actual structure of the compound.

As already stated, the ring formula for benzene consists of the hexagon, with one carbon atom at each angle and one hydrogen atom attached to each carbon. These hydrogen atoms can be removed and replaced by other elements, representing actual chemical substitution. In actual chemical computations the plain hex-

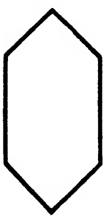

Fig. 138
The hexagonal symbol for benzene is called the benzine ring.

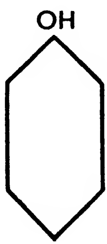

Fig. 139
Substitution of OH for 1st H produces ordinary phenol.

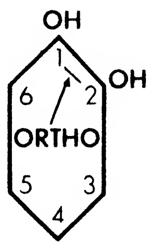

Fig. 140
Substitutions at angles 1 and 2 produce an "ortho" compound.

agon shown in Fig. 138 represents benzene. However, whenever any substitutions are made, the substitutions only are shown.

As one example of substitution (Fig. 139) we shall remove one **H** and substitute an **OH**. Here we have a benzene plus hydroxyl. Therefore we might assume

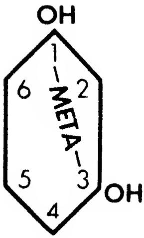

Fig. 141
Substitutions at 1 and 3 produce "meta" compound.

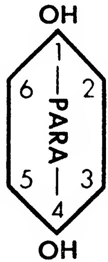

Fig. 142
With substitutions at 1 and 4, the product is a "para" compound.

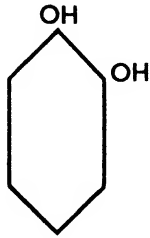

Fig. 143
Orthodihydroxybenzene, more commonly known as pyrocatechol.

that this compound is "hydroxy-benzene." This is quite correct. However, hydroxybenzene itself is a parent compound from which a large number of compounds is made by further substitution, and for that reason we give it a special name of its own which will distinguish its entire group. This name is **phenol**, and the compound shown (the parent hydroxybenzene) is the phenol or carbolic acid of commerce.

Let's go a step further and add another **OH** in place of a second **H**. The first substitution was made at angle No. 1, but now we have a choice of placing the second one at angle 2, angle 3, or angle 4, and by so doing we may produce three distinct compounds. Therefore before proceeding, suppose we consider Fig. 140. Here we see that when substitutions occur in

angles 1 and 2 we have an **ortho** compound. When the substitutions are in angles 1 and 3 (Fig. 141) we have a **meta** compound; and when they are in positions 1 and 4 (Fig. 142) we have a **para** compound. Therefore, suppose we start with the second **OH** in the second position. How shall we name the compound?

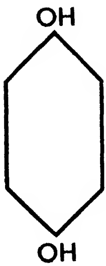

Fig. 144
Paradihydroxybenzene, known to the amateur as hydroquinone.

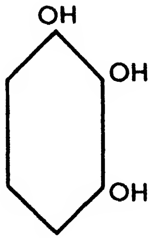

Fig. 145
1-2-3 trihydroxybenzene. This is the formula for pyro (pyrogallol).

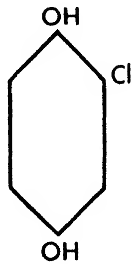

Fig. 146
Dihydroxy-chlorbenzene, commonly referred to as chlorhydroquinone.

Our first substitution was hydroxybenzene, but now we have two hydroxyls, so we will call this new compound **di-hydroxybenzene** to show that there are two hydroxyls. Again we will make a double substitution, but this time we will place the second **OH** in the fourth position. As we see in Fig. 142 we again have di-hydroxybenzene. Here are two compounds of the general formula $\mathbf{C_6H_4(OH)_2}$. If they are the same thing, this is quite satisfactory, but it happens that they are two quite different compounds. How can we distinguish them? Referring to the illustrations we see that Fig. 143 has substitutions in the ortho position, while in Fig. 144 they are in the para position. Therefore, we can call one ortho-di-hydroxybenzene, and the other para-di-hydroxybenzene. However, modern chemical

practice tends to revert to the simplest forms possible, so the compound shown in Fig. 143 will also be known as **1-2 dihydroxybenzene**, and that in Fig. 144 as **1-4 dihydroxybenzene**, the figures designating the positions of substitution.

Familiar Names of Benzene Compounds.

This may seem to be only of the slightest interest to the photographer, but perhaps we may find that it really is of some importance. In the past it was the practice to give chemical compounds arbitrary names which might or might not have reference to their actual structure. Unfortunately these names stick, and those to whom they are familiar refuse to give them up in favor of the simpler and more exact chemical names. But if chemical names were used commonly, you would be quite familiar with the two dihydroxybenzenes we have discussed, because orthodihydroxybenzene is **pyrocatechol,** and paradihydroxybenzene is our familiar friend, **hydroquinone.**

If we go a step further and substitute three **OH** groups for the hydrogens of positions 1-2-3, we have the formula shown in Fig. 145, which is **1-2-3 trihydroxybenzene,** more commonly known as **pyrogallol, pyro,** and **pyrogallic acid** (the latter not preferred).

Most of us are familiar with the fact that chlorine and bromine, members of the family of which iodine is the best known, are used to make the "chlorides" and "bromides" of photography. It happens that these elements also enter into the making of developers. If we start with hydroquinone (Fig. 144) and replace the No. 2 hydrogen with either chlorine or bromine we have the compounds shown in Figs. 146 and 147. These we might call dihydroxy-chlor-benzene and dihydroxy-brom-benzene respectively, but instead we shall call them **chlorhydroquinone** and **bromhydroquinone**

respectively. These compounds have the same common name in photography—**adurol.** One maker uses chlorine while another uses bromine.

The use of the photographic term **hydroquinone** for the 1-4 dihydroxybenzene is not a departure from our principles. We have already seen that hydroxybenzene is chemically known as **phenol.** Likewise we have a compound in which positions 1 and 4 are occupied by oxygen alone, which we might call **1-4 dioxybenzene,** but which chemists call **quinone** because it is the basic member of a family group which has certain characteristics shared by no other group. The change from quinone to hydroquinone and back again is easily made. So, while we should use the correct chemical terms for the 1-2 and 1-3 dihydroxybenzenes, it is perfectly correct to call the 1-4 group by its more common name, **hydroquinone.** (The 1-3 dihydroxybenzene or "resorcinol" is of little interest here.)

Our next step takes up the substitution of the ammonia-like radical $\mathbf{NH_2}$. We will find in photography that the terms **amido** and **amino** are used almost interchangeably. In our elementary discussion we will not split hairs, as both groups are formed by substitution of ammonia for one or more hydrogen atoms, and thus will often have the formula $\mathbf{NH_2}$. We will not go further in following out the complete cyclic changes, but consider only forms which interest us.

Figure 148 shows a phenol in which the fourth position hydrogen has been replaced by the amino group. This gives us 1-hydroxy-4-amino-benzene or, more simply, 4-aminophenol, or para-aminophenol, which we know as **paraminophenol.** In Fig. 149 the methyl radical $\mathbf{CH_3}$ has been added to the amino radical in the para position of phenol, thus giving us **paramethylaminophenol** (also called monomethylparaminophenol). The sulfate of this compound is the common developer **metol.**

If we substitute the radical **CH_2OH** for one of the hydrogen atoms of benzene we obtain **benzyl alcohol.** Suppose we start with the original benzene ring and substitute **OH** in position 1, substitute the amino group in the para or fourth position, and the benzyl group in the second position. We then have the formula shown

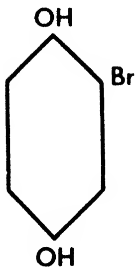

Fig. 147
Developing agent with similar properties is bromhydroquinone.

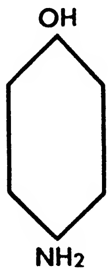

Fig. 148
Amino radical in 4th position indicates paraminophenol.

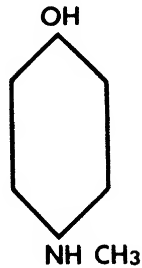

Fig. 149
Paramethylaminophenol, the sulfate of which is ordinary metol.

in Fig. 150. This we call para-amino-ortho-hydroxy-benzyl alcohol, but some of the hyphens are left out, making it **paramino-orthohydroxy benzyl alcohol.** This is known as **edinol.**

Another amino substitution of interest to us is that shown in Fig. 151 in which an amino hydrogen has been replaced by the acetic acid radical. We might better consider it as glycine (NH_2CH_2COOH), in which one H of the molecule has been replaced by the phenol ring. This is then known as **parahydroxy-phenylamino acetic acid** or simply **parahydroxyphenyl glycin,** which we have come to know as **glycin.** Unfortunately, this name is almost identical with the chemical name "glycine," a totally different product.

The next amino substitution which we shall con-

sider is the double amino substitution in benzene in the para position. This gives us **1-4 diaminobenzene,** which we know by its older name of **paraphenylenediamine** (Fig. 152).

That favorite developer of many advanced workers, **amidol,** presents a slightly new form of substitution. Here we have the phenol ring—that is, benzene

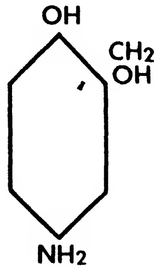

Fig. 150
Paramino-orthohydroxy benzyl alcohol. Its common name is Edinol.

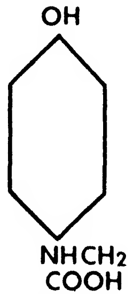

Fig. 151
Parahydroxyphenylamino acetic acid is the well-known glycin.

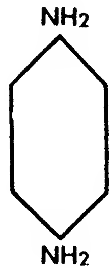

Fig. 152
1-4 diaminobenzene, commonly called paraphenylenediamine.

with **OH** in the No. 1 position. Amino groups have been substituted in the 2 and 4 positions, so that our old friend amidol appears to be **2-4 diaminophenol** (Fig. 153). Actually, however, amidol is the **hydrochloride** salt of the above named compound, which is shown in Fig. 154.

Eikonogen has never been widely used in this country, but we shall include it largely because it gives us an interesting form of substitution, in that it involves a double ring and the introduction of the **sulfonic acid** radical. The double benzene ring is formed by joining positions 5 and 6 of one ring with 2 and 3 of another (Fig. 155), thus causing one carbon atom to act both as 2 and 6 and another to act as 3 and

5. The double ring then contains ten carbon atoms instead of twelve, as would be the case in two separate complete rings. The positions are numbered clockwise, from 1 to 8, omitting the positions which are common to both rings. This nuclear double ring is known as the **naphthalene** ring.

In Fig. 156 we show such a double ring with $\mathbf{NH_2}$

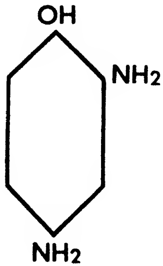

Fig. 153
One hydroxyl and two amino radicals give 2-4 diaminophenol.

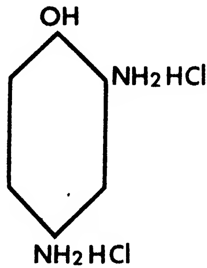

Fig. 154
The hydrochloride salt of 2-4 diaminophenol is ordinary amidol.

in the first position, **OH** in the second position, and **sulfonic acid** radical $\mathbf{HSO_3}$ in the sixth position, and we have **1-amino-2-naphthol-6-sulfonic acid**, which is the developer **Eikonogen.**

Finally, we also have the possibility of direct addition of total compounds. The combination of hydroquinone and metol base gives us **metoquinone. Chloranol** is formed by the addition of chlorhydroquinone and metol base, and incidentally indicates its close relationship to metoquinone. Many other combinations can be made to produce complex compounds that are used in photography as developing agents.

It is hoped that this brief discussion will have served to give some insight into the meaning of chemi-

cal names, particularly of those commonly used in connection with developing agents. The information may not be of the highest importance, but when a name means something it is usually far more valuable than if it is merely an arbitrary sound. Thus we see that chemical names, instead of being merely long, mean-

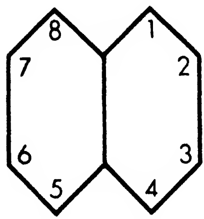

Fig. 155
Double benzene ring is known as the naphthalene ring.

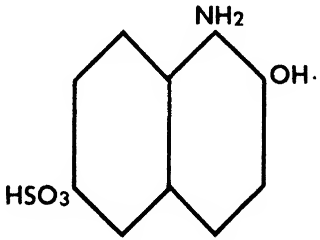

Fig. 156
1-amino-2-naphthol-6-sulphonic acid, the once-popular Eikonogen.

ingless words, are really abbreviated descriptions of the actual materials.

Developers and Their Trade Names.

Now let us consider some of the developers, with particular regard to their peculiar characteristics. However, to avoid confusion and repetition, we shall first give a list of some trade names and other synonyms so that the descriptive list will include only one developer of each type. The trade name situation is unfamiliar to many amateurs. The name **metol** was registered as a trade mark by a foreign chemical manufacturer, so that other manufacturers, while making the same identical compound, were prohibited from

using this name. Hence, each maker used a name of his own, with the result that we now have more than a dozen developers, all of which are simply metol.

Trade Name or Synonym	Commonly Used Name	Chemical Name
Acrol	Amidol	Diaminophenol-di-hydro-chloride
Actival	Chemical name	Paraminophenol
Adurol	Chemical name	Chlor- or bromhydroquinone
Amidol	Same	Diaminophenol-di-hydro-chloride
Athenon	Glycin	Parahydroxyphenyl glycin
Azol	Chemical name	Paraminophenol
Catechin	Pyrocatechol	Orthodihydroxybenzene
Catechol	Pyrocatechol	Orthodihydroxybenzene
Certinal	Chemical name	Paraminophenol
Chloronol	Chemical name	Chlorhydroquinone
Chloroquinol	Chemical name	Chlorhydroquinone
C. H. Q.	Chemical name	Chlorhydroquinone
Claritol	Metol	Paramethylaminophenol sulfate
Diamine	Chemical name	Paraphenylenediamine (base)
Diamine P	Chemical name	Paraphenylenediamine (base)
Diamine H	Chemical name	Paraphenylenediamine hydrochloride
Dianol	Chemical name	Paraphenylenediamine (base)
Dianol	Amidol	Diaminophenol-di-hydro-chloride
Diolene	Chemical name	Orthophenylenediamine
Elon	Metol	Paramethylaminophenol sulfate
Enol	Metol	Paramethylaminophenol sulfate
Genol	Metol	Paramethylaminophenol sulfate
Glycin	Same	Parahydroxyphenyl glycin
Hydrochinone	Hydroquinone	Paradihydroxybenzene
Hydroquinone	Same	Paradihydroxybenzene
Kachin	Pyrocatechol	Orthodihydroxybenzene
Kodelon	Chemical name	Paraminophenol (oxalate salt)
Kodurol	Glycin	Parahydroxyphenyl glycin

Metol	Same	Paramethylaminophenol sulfate
Monazol	Glycin	Parahydroxyphenyl glycin
Monol	Metol	Paramethylaminophenol sulfate
Monotol	Metol	Paramethylaminophenol sulfate
Photol	Metol	Paramethylaminophenol sulfate
Pictol	Metol	Paramethylaminophenol sulfate
P. D. H.	Chemical name	Paraphenylenediamine hydrochloride
Pyro	Pyro	1-2-3 Trihydroxybenzene
Pyrogallic acid	Pyro	1-2-3 Trihydroxybenzene
Pyrogallol	Pyro	1-2-3 Trihydroxybenzene
Pyrocatechin	Pyrocatechol	Orthodihydroxybenzene
Pyrocatechol	Same	Orthodihydroxybenzene
Quinol	Hydroquinone	Paradihydroxybenzene
Quinotol	Chemical name	Chlorhydroquinone
Rhodol	Metol	Paramethylaminophenol sulfate
Rodinol	Chemical name	Paraminophenol (sodium salt)
Satrapol	Metol	Paramethylaminophenol sulfate
Scalol	Metol	Paramethylaminophenol sulfate
Veritol	Metol	Paramethylaminophenol sulfate
Viterol	Metol	Paramethylaminophenol sulfate

So much for trade names and synonyms. Now let's revise the above list and, starting with the commonly used name, give the synonyms for each.

Amidol—Acrol, Dianol.

Chlorhydroquinone—Adurol, Chloronol, Chlorquinol, C.H.Q., Quinotol.

Glycin—Athenon, Kodurol, Monazol.

Hydroquinone—Hydrochinone, Quinol.

Metol—Claritol, Elon, Enol, Genol, Monol, Monotol, Photol, Pictol, Rhodol, Satrapol, Scalol, Veritol, Viterol.

Orthophenylenediamine—Diolene.
Paraphenylenediamine—Diamine, Diamine P, Dianol.
Paraphenylenediamine Hydrochloride—Diamine H, P.D.H.
Paraminophenol—Actival, Azol, Certinal, Kodelon, Rodinol.
Pyro—Pyrogallic acid, Pyrogallol.
Pyrocatechol—Catechin, Catechol, Kachin, Pyrocatechin.

Developer Characteristics.

This leaves us with a much smaller number of items to describe. In the following list, the characteristic factors are not always identical, but those which have a particular bearing upon the individual developer are given. When the agent has some particular developing characteristic, it is given; otherwise the general reactions are given instead. Thus, an agent may simply be active or inactive, or it may have a positive color effect, such as warm black, blue-black, and so forth. When no information is given about a certain characteristic, it may be assumed that there is nothing unusual to be found in that direction.

Amidol (2-4 Diaminophenol - di - hydrochloride). Reduction potential 30 to 40. This agent needs no alkali, producing an active developing solution simply by adding sulfite. It is so active, however, that the solution should be used within an hour or so after mixing. Although used by many pictorialists for negative development, it is chiefly known for the beautiful blue-black image it gives with most bromide papers. It stains the fingers, and must be handled carefully.

Chlorhydroquinone. This developer was originally introduced into this country as an importation under the name **Adurol.** The chemical names given vary, and include in addition to chlorhydroquinone, 1-2-4 chlor-

dihydroxybenzene and 1-2-5 chlordihydroxybenzene. The bromide compound, which is the same except for the substitution of "brom" for "chlor" and which has the same photographic action, was also sold as an imported Adurol. Its action is similar to hydroquinone, but it is more active and does not react so easily to variations in temperature. It may be substituted for hydroquinone in any formula provided it is used in the proportion of 144.5 parts for each 110 parts of hydroquinone indicated, or roughly 14.5 to 11. Used with chlorobromide papers it tends to give warmer tones than usual.

Edinol (Paramino-orthohydroxybenzyl alcohol). This was once a popular developing agent of moderate activity, but has not been available during recent years.

Eikonogen (Sodium aminonaphthol sulfonate). Highly active, but like Edinol is not available now.

Glycin (Parahydroxyphenyl glycin). Reduction potential, 1.6. Although of low activity, this is one of the best single-agent finegrain developers we have. As it is practically insoluble in water and alcohol, but readily so in sulfite solution, it is necessary to dissolve the sulfite first. It is almost entirely free from oxidation by air, and is thus a favorite for long-time tank development. i.e., from 1 to 48 hours. Used as a paper developer, it produces beautiful warm tones on chlorobromide papers.

Hydroquinone (Paradihydroxybenzene). Reduction potential 1. Used by itself hydroquinone is a high-contrast developer, and for that reason is often used alone with a caustic accelerator for the development of line-copy negatives. Its high sensitivity to bromide and its freedom from fog make it particularly valuable in such work. Its widest application, however, is in combination with metol to make the popular M-Q type of developer. It should never be used at a temperature below 65° F., and at 55° F. it becomes practically inert.

Chlorhydrochinon (and brom-) are less sensitive to temperature, and for this reason are sometimes substituted for hydroquinone.

Metol (Paramethylaminophenol, although the metol on the market is usually the sulfate of the base compound). Reduction potential, 20. Less soluble in sulfite than in plain water, therefore it should be dissolved before the sulfite is added. Sulfite at times produces a precipitate when added to a solution of metol. This precipitate is metoquinone, and is only produced when hydroquinone is also in solution. Will act slowly when accompanied only by sulfite, but is usually used with an alkali. Having a high potential it acts quickly, but brings up shadows almost as rapidly as highlights, thus producing a soft or low contrast result. For this reason it is usually mixed with hydroquinone or similar low-potential agent which builds up the highlights rapidly, leaving the shadows thin, and thus giving negative contrast. The same type of mixed developer is also used in printing.

Meritol. A combined form of pyrocatechol and paraphenylenediamine. Proposed as a finegrain developer of considerably higher activity than p-diamine alone.

Metoquinone. This is simply a product of metol base and hydroquinone. It has much the qualities of the mixed developer and has been advocated especially for reversal development.

Orthophenylenediamine. This is simply the 1-2 diamino benzene instead of the 1-4 or para form. It is also sold as Orthamine and Diolene. Though not as well known as the paraphenylenediamine, its action as a developer is quite similar.

Paraphenylenediamine (also called 1-4 Diaminobenzene). Used both as the base and as the hydrochloride, with a reduction potential of 0.4 in both cases. Widely favored as a finegrain developer, but probably

overrated as such. It is more valuable as an activator of the developer when a reducer such as metol or glycin is used for the actual reduction. Has been known more than a half century, but only recently has been regarded as satisfactory for photographic use, although it does produce a developing solution of normal activity when combined with a caustic alkali.

Paraminophenol (Hydrochloride) (also Paramidophenol). Reduction potential, 6. Tends to give less fog than other agents of similar potential, and is thus especially adapted to making high-temperature developing solutions. In solutions of strong alkali, the aminophenolate is formed, which is highly soluble and permits developing solutions of high concentration to be formed. This characteristic action is the basis for such concentrates as Rodinal, Azol, Certinal, and others.

Pyro (1-2-3 Trihydroxybenzene). Reduction potential, 16. The oldest of developers and the stand-by of the "old timers," particularly those who still develop ortho emulsions by inspection. Pyro, as it is generally known, produces a yellow to brown stain unless used with a large amount of sulfite, but the stain follows the image and is in many cases a help rather than otherwise. Used with a weak alkali and low sulfite it makes an excellent finegrain developer, as the stain aids in concealing the grain structure. Used with caustic soda (about 3 parts soda to 10 pyro, or with about 4 parts caustic potash to 10 of pyro), the monophenolate is formed, producing a maximum-energy developer. However, any excess of the caustic induces strong chemical fog.

Pyrocatechol (Orthodihydroxybenzene). Reduction potential, 7. This developer, sold under a variety of names, is midway between pyro and hydroquinone in activity. It is a somewhat slow-working developer, and subject to unusually full control so that either hard

or soft gradation can be obtained. It is often suggested both as a semi-finegrain developer, used in dilution, or as a control developer for separation negatives in color work.

There are many developers on the market at the present time under strange and terrible names. Some of these are simply well-known formulas made up under a fancy label and a novel name. There are a few which do incorporate novel constituents, such as **Gradol,** which is a developer of the paraminolphenol (Rodinal) type, and **Rubinol,** which is said to be a pyrogallol derivitive. Any claims as to "new" developing agents should be regarded suspiciously. It has been shown how the organic developers are divided into a few groups of closely related compounds, and all possible variations of these groups have been studied. It is far more likely that the "new" developing agent will bear a close relation to an old and familiar one, and that nothing but the name is new.

Test for Identifying a Developing Agent.

There may be times when you will want to know how to identify a developing agent. A test which was originated in Europe serves quite satisfactorily. This is really a double-step method of analysis, the first of which is based upon differential solubilities and the second of which is a colorimetric system of testing, quite in line with modern colorimetric methods. First we shall consider the relative solubilities of the various developers. In the following chart the letters **s** and **i** indicate that the developer is soluble or insoluble.

For the second test a 5% solution of the agent is prepared. To this are added various reagents, and the color effect is noted. In the next table we shall make use of the following abbreviations: **V**=violet; **Bl**=blue; **BG**=blue-green; **G**=green; **OG**=olive green;

Developing Agent	Alcohol	Ether	Water
Amidol	s	i	s
Chlorhydroquinone	s	s	s
Glycin	i	i	i
Metol	i	i	s
Hydroquinone	s	s	s
Paraphenylenediamine hydrochl.	i	i	s
Paraminophenol hydrochloride	s	i	s
Pyrogallol	s	s	s
Pyrocatechin	s	s	s

R=red; **Br**=brown; **Bk**=black; **Y**=yellow; **Gr**=gray; **W**=white; l=light; **d**=dark; +=changing to. Thus, if we have **Y+dBr** it means that the color is first yellow and then changes to dark brown;* indicates no change when the reagent is added.

There are seven reagents:

1. Sodium carbonate. Add few drops 20% solution to developer.
2. Ammonium vanadate. Use 1 or 2 drops 5% solution.
3. Potassium hydroxide. Few drops 5% solution are used.
4. Potassium ferricyanide plus sodium carbonate; 10% solution of ferricyanide followed by reagent 1.
5. 10% solution potassium ferricyanide.
6. 10% solution ferrous sulfate.
7. 2% solution ferric chloride.

Developing Agent	Reagents						
	1	2	3	4	5	6	7
Amidol	Bl	R	YBr		R		
Chlorhydroquinone	Y+Br	*	Y+Br	G+RBr			RBr
Hydroquinone	Y+Br	*	Y+Br	Y+Br			dG
Metol	Y+Br	OG+V	YBr	YBr+dRBr			lR
Paraphenylenediamine (hydro)	*	G+OG	*	G			dG
Paraminophenol-hydrochloride	*	BG	V	Decolorized			
Pyrogallol	Y+Br	B	Y+Br	Br		B	(6+1=BV)
Pyrocatechin	*	V	GBr	G+GBr		G	(6+1=RV)

It must be recognized that in a developing solution (ready to use) we have certain difficulties to face. In the first place carbonate is present in almost every case, so that test No. 1 already is performed. Sulfite is also present in most cases, as a preservative, and this will interfere. The presence of carbonate obstructs the other tests with the exception of No. 4. Another difficulty lies in the presence of mixed agents in many developers; and finally, in the more complex solutions there is such a mixture that almost any conceivable result might be obtained. Therefore, these tests are really valuable only when the developing agent itself is available.

Photographic Chemicals.

In making up a list of the chemicals used in photography, it is difficult to know just where to draw the line. In our own laboratory we stock between 400 and 500 different chemicals, most of them actually used in some type of photographic work. On the other hand, many amateurs do good work with a chemical supply limited to the following: Metol, hydroquinone, sodium sulfite, sodium carbonate, sodium thiosulfate, potassium bromide, potassium alum, and acetic acid.

Between these two extremes, a line must be drawn. Therefore, we shall try to limit this list to those preparations which are of definite value in compounding photographic solutions of recognized value, and eliminate both obsolete processes and those of an experimental nature.

Acetic Acid (Pyroligneous acid) CH_3COOH. Contained in vinegar in dilute form. Ordinarily used as "glacial" (99%) or as a 28% solution. Used most commonly in bringing hypo baths to the desired degree of acidity and in short-stop baths. The ordinary 28% acid called for in many formulas is made from 3 parts

glacial acetic acid diluted with 8 parts of water. Salts of this acid are the acetates, some of which are used in photography.

Acetone (Dimethyl ketone) $(CH_3)_2CO$. Used as a substitute for alkalis in some developers. As a solvent of celluloid it is widely used for cementing films.

Alcohol, Ethyl. Ordinary or grain alcohol. C_2H_5OH. The denatured variety is commonly made by the addition of methyl alcohol, CH_3OH. Pure methyl alcohol is also widely used in photography. In most cases they are interchangeable. Alcohol is added to some developers to increase the solubility, and it is also used as a rapid drying agent. However, the latter procedure is not recommended if the negative has any permanent value.

Alum. This is a family name given to many double sulfates.

Ammonium Alum. $(NH_4)_2SO_4AL_2(SO_4)_3$. Not widely used.

Ammonium Bichromate. $(NH_4)_2Cr_2O_7$. May be used to render gelatin insoluble following exposure to light, the basis of the so-called "bichromated gelatin" reactions. Other bichromates also are used.

Ammonium Chloride. NH_4Cl. The usual active agent in rapid fixing solutions.

Ammonium Persulfate. $(NH_4)_2S_2O_8$. Used as a flattening reducer for negatives.

Borax (Sodium tetraborate). $Na_2B_4O_7$. A weakly alkaline material used as an accelerator in finegrain and true-gradation developers.

Boric Acid. H_3BO_3. Also known as boracic acid. Added to developers containing borax to maintain a constant *p*H (acidity) during use. This action is known as "buffering."

Citric Acid. $(CH_2COOH)_2 \cdot C(OH)COOH$. A weak organic acid used chiefly as a constituent of clearing baths in some photographic processes.

Copper Sulfate (Blue vitriol) $CuSO_4$. Used in making up certain bleaching solutions and in copper toning.

Cyanine. $C_{28}H_{35}N_2I$. Orthochromatic sensitizing dye.

Formalin (Formaldehyde; Formic aldehyde) HCOH. Emulsion hardener to prevent swelling of gelatin. A 5-minute bath in a 10% solution of commercial formalin will enable an emulsion to withstand even boiling water. Weaker solutions are used ordinarily, but some photographers remove negatives from hypo, rinse in a half-dozen changes of water, treat 5 minutes in 10% formalin, and then ensure thorough washing by completing the wash in boiling water. The great objection is that formalin-hardened negatives sooner or later become brittle and crack up into dust.

Glycerin. $C_3H_5(OH)_3$. Used to prevent too rapid drying and excessive curling of prints, and to some extent as a physical restrainer in developing solutions.

Hydrogen Peroxide. H_2O_2. A powerful oxidizing agent. Used in 5% solution as final hypo eliminator, and when mixed with an alkali will act as a developer. Used in stronger solution to remove spots from wet prints.

Kodalk. Trade name for an alkali of the borax type. Negative developers using this alkali are ordinarily preferable to those using the stronger sodium carbonate. More active than borax.

Lead Nitrate. $Pb(NO_3)_2$. Used in lead intensification, and has also been used in some toning baths.

Mercuric Chloride (Bichloride of mercury, Corrosive sublimate) $HgCl_2$. Active poison. Used widely as a bleaching agent preceding intensification by various agents.

Potassium Alum. $K_2SO_4 \cdot Al_2(SO_4)_3$. The ordinary "white" alum commonly used as the hardening agent in hypo baths.

Potassium Bichromate. $K_2Cr_2O_7$. Used for sensitizing gelatin for the various bichromate processes.

Potassium Bromide. KBr. The principal use for this compound is that of a restrainer in developing solutions. It is also used in various bleaches preceding toning, and in the manufacture of emulsions.

Potassium Carbonate. K_2CO_3. Occasionally used as an alkali in developers, but is so deliquescent that the sodium salt is preferred.

Potassium Chrome Alum (Chrome Alum) $K_2SO_4 \cdot Cr_2(SO_4)_3$. Used at times as hardening agent in hypo, but more generally as the hardening agent in the chrome-alum-bisulfite stop bath.

Potassium Cyanide. KCN. A highly active and deadly poison. Although used in various bleaching baths and for cleaning Daguerreotypes, the amateur is advised not to include it in his laboratory supplies. Iodine will usually serve every bleaching purpose required in ordinary work.

Potassium Ferricyanide. $K_3Fe(CN)_6$. This is not nearly as dangerous as the cyanide and should not be confused with it. Although to some degree poisonous, it is not more so than many compounds used in photography. It is used in reducing baths, bleaches, and some toning baths.

Potassium Hydroxide. KOH. Caustic potash. Occasionally used in high-activity developers, but the sodium salt is preferred.

Potassium Iodide. KI. Used in some intensifiers, in making emulsions, and in other photo formulas.

Potassium Metabisulfite. $K_2S_2O_5$. Used in some developers, but more commonly in making acid fixing baths. The sodium bisulfite is more commonly used.

Potassium Permanganate. $KMnO_4$. Widely used in photography as an ingredient of bleaching baths, in intensification, reduction, and reversal, and as a hypo eliminator and hypo test.

Salicylic Acid. $C_6H_4COOH \cdot OH$. Very rarely used as a substitute for other organic acids in photography.

Silver Nitrate. $AgNO_3$. Used in various sensitizing baths, in the manufacture of photographic emulsions, in physical developing and intensifying solutions, and in toning baths. In pure state it is not sensitive to light but in the presence of any organic matter it turns dark when exposed to light.

Sodium Acetate. $NaC_2H_3O_2$. The acetic acid salt of sodium used in toning baths.

Sodium Bicarbonate. $NaHCO_3$. Used in toning. Do not confuse with the carbonate.

Sodium Bisulfite (Sodium acid sulfite). $NaHSO_3$. Used in the preparation of acid fixing baths and occasionally in developers.

Sodium Carbonate. Na_2CO_3. The most common of all accelerators in photography. Available in three forms, anhydrous, monohydrated, and crystal; 286 parts of crystal equal 100 parts anhydrous, while 100 parts of the monohydrate equal 85 parts of the anhydrous form.

Sodium Hydrosulfite. $Na_2S_2O_4$. The name commonly applied to sodium hyposulfite to prevent confusion with the ordinary "hypo," which is really sodium thiosulfate. "Hypo" is **not** sodium hyposulfite; the latter is used as a clearing and bleaching agent and for chemically exposing emulsions in the reversal process. Immersion of a silver emulsion in this solution instead of "fixing" causes all its silver salts to be converted immediately into the metallic form.

Sodium Metaborate. $Na_2B_2O_4$. Accelerator, more active than borax, but with many of its good qualities.

Sodium Phosphate (Trisodium phosphate). Na_3PO_4. This is the tribasic phosphate, and is used in some forms of finegrain development as the alkali or accelerator. Also a water softener.

Sodium Sulfate. Na_2SO_4. Used to prevent swell-

ing of gelatin in developers designed for use at high temperatures.

Sodium Sulfide. Na_2S. A salt translucent gray when pure, but usually of brownish color with an odor of rotten eggs. This chemical is used as the sulfiding agent in sepia toning by redevelopment. It must not be kept near sensitive materials such as papers, films, plates, etc.

Sodium Sulfite. Na_2SO_3. Used as a preservative and as a silver solvent in developers. When exposed freely to air it takes on oxygen and turns into the more or less inert sulfate.

Sodium Thiosulfate. $Na_2S_2O_3$. The ordinary "hypo" used in a fixing bath.

Uranyl Nitrate (Uranium nitrate). $UO_2(NO_3)_2$. Used principally in uranium toning and intensification.

These forty-three chemicals together with the developing agents already described include about all which the average amateur will be called upon to use. However, almost every new process calls for some new ingredient. Quite often this new ingredient is not available in the photographic shops. In this case apply to some large chemical supply house; if the compound is organic it can usually be obtained from the Organic Chemicals Division of Eastman Kodak Co.

Weights and Measures.

Every amateur photographer should eventually adopt the metric system for his laboratory work. This is advised not alone because of the essential simplicity of the metric system, but because the English systems are so numerous and so confusing. We have the confusion arising from the differences between Avoirdupois and Apothecaries' weight, and between liquid and dry measure. English systems are based upon an arbitrary and illogical arrangement of units which bear

no fundamental relationship to each other, and are therefore almost impossible to remember.

Unit	British	Metric	American	Metric
1 minim........	1/480 oz.....	0.0592 cc	1/480 oz.....	0.0616 cc
1 drachm......	60 minims...	3.5515 cc	60 minims...	3.6966 cc
1 ounce.........	480 minims..	28.41 cc	480 minims..	29.574 cc
1 pint..........	20 oz.........	568.251 cc	16 oz.........	473.18 cc
1 quart.........	40 oz.........	1136.5 cc	32 oz.........	946.36 cc
1 gallon.......	4 qt.........	4546.0 cc	4 qt.........	3785.43 cc

If we remember that the British use the Apothecaries' system with 480 grains to the ounce and we use the Avoirdupois with (shall we say "exactly") 437½ grains to the ounce; and that the British quart is larger than a liter, while the American quart is barely 95% of that standard volume, we can keep our formulas straight. But who is going to remember?

The Metric System has one universal relationship, and that relationship is 10. Every consecutive unit is either 1/10 or 10x the preceding one, and this holds for length, area, weight, liquid, and dry volume; even the temperature scale divides the range between freezing and boiling into 100 equal degrees. The whole system is based on the distance between the pole and the Equator. A unit fraction of this distance is the **meter**; likewise, 1/10 meter is a decimeter, 1/100 meter is a centimeter, 1/1000 meter is a millimeter. On the ascending scale 10 meters equal 1 dekameter, 100 meters equal 1 hectometer, and 1000 meters equal 1 kilometer.

The unit of volume is the cubed decimeter or **liter.** One liter is supposed to be the volume of 1000 cc., but recent refinements have made an unfortunate distinction between the cubic centimeter (cc.) and the milliliter (ml.). However, as the difference is only 27 parts per million, in our field we may make use of the two units interchangeably because an error of one in thirty thousand is negligible.

The unit of weight is the **gram**, which is the weight of one cubic centimeter of water at a specified temperature; one kilogram is equal to 1000 grams, or to the weight of a liter of water.

The following comparisons between Avoirdupois and Metric are interesting:

1 ounce (Avoirdupois—American)	**=28.35 grams**
1 ounce (Apothecaries'—British).	**=31.10 grams**
1 grain (all forms)...............	**= 0.0648 grams**
1 minim (British)...............	**= 0.0592 cc.**
1 minim (American)............	**= 0.0616 cc.**
1 fluid ounce (British)...........	**=28.41 cc.**
1 fluid ounce (American)........	**=29.574 cc.**
1 milligram.......................	**= 0.0154 grain**
1 gram..........................	**=15.432 grains**
1 cc............................	**= 0.0338 fl. oz.** (U.S.)

Since formulas may be given in either Avoirdupois or Metric, and since amateur photographers usually have balances and graduates calibrated in one or the other of these two systems, it is often necessary to convert a formula. For convenience the tables on the next page are included to show the relationship of units in the two systems. (British weights and measures are disregarded; the figures used are U. S. standards.)

In converting formulas, we have not only the weights of the materials to consider, but the amount of solution to be made. Therefore it is necessary first to determine how many units of solid (grains or grams) are contained in a given amount of liquid (ounces or cc). In the case of a formula which calls for a given number of grains per 32 ounces of solution, divide the grains by 32. This gives the number of grains per ounce of solution. The resulting figure can be multiplied by a factor which will give the number of grams per liter, then that value is divided or multiplied according to the amount of solution we are going to make.

CONVERSION TABLES

Avoirdupois to Metric Weight

Pounds (lb.)	Ounces (oz.)	Grains (grain)	Grams (g.)	Kilograms (kg.)
1	16.	7000	453.6	0.4536
0.0625	1	437.5	28.35	0.02835
		1	0.0648	
	0.03527	15.43	1	0.001
2.205	35.27	15430	1000	1

U. S. Liquid to Metric Measure

Gallons (gal.)	Quarts (qt.)	Ounces (Fluid) (fl. oz.)	Drams (Fluid) (fl. dr.)	Cubic Centimeters (cc.)	Liters (liter)
1	4	128	1024	3785	3.785
0.25	1	32	256	946.3	0.9463
		1	8	29.57	0.02957
0.000975	0.0039	0.125	1 (60 mins.)	3.697	0.003697
		0.03381	0.2705	1	0.001
0.2642	1.057	33.81	270.5	1000	1

Long or Linear to Metric Length

Yards (yd.)	Feet (ft.)	Inches (in.)	Millimeters (mm.)	Centimeters (cm.)	Meters (m.)
1	3	36	914.4	91.44	0.9144
0.333	1	12	304.8	30.48	0.3048
0.0277	0.0833	1	25.4	2.54	0.0254
0.00109	0.00328	0.03937	1	0.1	0.001
0.0109	0.0328	0.3937	10.0	1	0.01
1.0936	3.2808	39.37	1000	100.0	1

To understand this more fully, let us consider a well-known formula and make the complete conversion. First, however, we shall want to know what the fixed factors are. These are easily determined. We know that there are 437.5 grains in an ounce. We also know that 1 liter is closely equivalent to 1000 grams. Then from the conversion table we learn that 1 grain

= 0.0648 grams, and 1 gram = 15.43 grains. We also learn from the conversion table that 1 fluid ounce = 29.57 cubic centimeters, and 1cc. = 0.03381 fl. oz.

Therefore if we divide 1000 (the number of cc. in one liter) by 29.57 we will have our first factor. However, we know from our conversion that one cubic centimeter equals 0.03381 ounces, therefore 1000 times this figure, or 33.81, is the desired factor. If there are 33.81 fluid ounces in a liter, and we have a concentration of material equal to one grain per ounce, we will then have 33.81 grains per liter. Now we wish to know how many grams per liter this equals. From our tables we learn that one gram equals 15.43 grains. Then we have the equation:

$33.81 \div 15.43 = 2.19149$ or, for our purposes, 2.19.

Therefore a concentration of one grain per ounce equals 2.19 grams per liter, and it follows of course that 2 grains per ounce equals 4.38 grams per liter, etc. Also, we can convert grains per 32 ounces to grams per liter; the factor is obtained by dividing 2.19 by 32 to get 0.06847. Thus:

(Grains per ounce) × 2.19 = Grams per liter
(Grains per 32 ounces) × 0.06847 = Grams per liter

Likewise, 1 gram per liter equals 15.43 grains per liter, or $(15.43 \div 33.81)$ 0.4563 grains per fl.oz. Therefore 32×0.4563 gives 14.60, the factor for converting grams per liter to grains per 32 ounces. Thus:

(Grams per liter) × 0.4563 = grains per ounce
(Grams per liter) × 14.60 = grains per 32 ounces

Let's take the following 20-ounce Avoirdupois formula for amidol developer and convert it into a Metric formula to make a 500 cc. solution:

Amidol Developer

Amidol	60 grains
Sodium sulfite, des	1 oz., 40 gr. (477.5 gr.)
Potassium bromide	12 grains
Water to make	20 ounces

The conversion is made in the following manner:

Chemical	Grains	Divide by 20 to get gr. per oz.	Multiply by 2.19 g. per L.	Divide by 2 to get g. per 500 cc.
Amidol	60	3.0	6.57	3.28 grams
Sodium sulfite	477.5	23.875	52.286	26.14 grams
Potassium bromide	12	0.6	1.314	0.65 grams
Water to make	20 oz.			500.0 cc.

Had the original formula called for a 32-ounce solution (water to make 32 ounces), each quantity could have been multiplied by the factor 0.06847 to give a direct conversion to grams per liter, then each figure divided by 2 to give grams per ½ liter (500 cc.).

Not only do you reduce formulas to grains per ounce and grams per liter for conversion between the two systems, but also for the purpose of comparing similar developer formulas. For example, you will find one formula for 32 ounces of solution, another for 24 ounces, and still another for 20 ounces. Then you may find one for 250 cc., one for 750 cc., and another for one liter. These have widely varying quantities of ingredients, but when you reduce them all to grains per ounce or grams per liter, you will often find that instead of seven or eight different formulas you have two or perhaps three, the other differences being due only to slight variation in quantities.

In our own laboratory every formula is subjected to a breakdown analysis. First, all synonyms and trade names are reduced to their common denomina-

tor. For example, our formulas show nothing but metol when that material is indicated in a formula by a trade name or synonym. True, we do not make use of the actual chemical name because it is cumbersome, but our formulas never show trade names where a common name can be used. This is done for just one reason—we must have a common ground for comparison of formulas from every source. Each formula is next reduced to a grams-per-liter basis, and then compared with a standard formula. The result is that while there are actually hundreds of formula cards, there are really only a few dozen different formulas!

In the case of prepared developing solutions we found that conventional organic analysis was far from satisfactory. Therefore during the past several years we have slowly developed a system of crystallographic and colorimetric analysis which appears to be satisfactory. It has not been described here simply because the instruments necessary for this work—precision colorimeter, refractometer, crystallographic microscope, crystal stage, monochromator—are not available to the average amateur, and the methods involve too much time and painstaking effort to be used simply for the satisfaction of curiosity.

Temperature.

Another factor is that of temperature. There is not so much reason for using the metric temperature scale unless you have a Centigrade thermometer. But in case you have occasion to convert from one system to the other, you will find the basis for conversion as follows: Zero Fahrenheit is 32 degrees below freezing, while zero Centigrade is freezing. Therefore 0° C. = 32° F. Likewise boiling point is 100° C. and 212° F. Therefore freezing to boiling is 100° C. and 180° F., a relation of 10 to 18, or 5 to 9. One degree

C. = 9/5 degree F., and one degree F. = 5/9 degree C. To convert Fahrenheit to Centigrade, subtract 32, multiply the remainder by 5, and divide by 9. To convert 90° F. to Centigrade, subtract 32 to get 58. Divide 58 by 9 to get 6.44444, multiply this by 5, and you obtain 32.222. Therefore 90° F. is the same as 32.22° C.

To convert Centigrade to Fahrenheit, the procedure is reversed; here it is necessary to multiply by 9, divide by 5, and then add 32. To convert 42° C. to Fahrenheit, first multiply by 9 to get 378, then divide this by 5 to get 75.6. This means that 42° C. equals 75.6° Fahrenheit degrees **above freezing.** Now add the 32 degrees necessary to bring 0° F. to freezing, and you get 107.6° F., the equivalent of 42° C.

Because this is a constant equation and somewhat complicated by the addition or subtraction of 32, the use of a comparison scale is convenient. This table follows:

Temperature Conversion Table

Temp. °C.	0	1	2	3	4	5	6	7	8	9
0	32.0	33.8	35.6	37.4	39.2	41.0	42.8	44.6	46.4	48.2
10	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2
20	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4	84.2
30	86.0	87.8	89.6	91.4	93.2	95.0	96.8	98.6	100.4	102.2
40	104.0	105.8	107.6	109.4	111.2	113.0	114.8	116.6	118.4	120.2
50	122.0	123.8	125.6	127.4	129.2	131.0	132.8	134.6	136.4	138.2
60	140.0	141.8	143.6	145.4	147.2	149.0	150.8	152.6	154.4	156.2
70	158.0	159.8	161.6	163.4	165.2	167.0	168.8	170.6	172.4	174.2
80	176.0	177.8	179.6	181.4	183.2	185.0	186.8	188.6	190.4	192.2
90	194.0	195.8	197.6	199.4	201.2	203.0	204.8	206.6	208.4	210.2

Photographic Emulsions.

There are literally hundreds of different photographic emulsions made throughout the world, yet all are of the same basic type. A close study will show that there are a far greater number of trade names

Fig. 157. Few photographers can resist this type of picture subject. Lighting will vary some with the time of day, but there is little choice of camera angle, and none of background.

than of really distinct emulsions. On the contrary, there are varieties in emulsions which are rarely heard of except by the comparatively small group of researchers and specialists who use them. All of this makes for confusion, and confusion concerning available material is disconcerting to the serious amateur.

We have already considered the general physical structure of the emulsion. It is made up of a gelatin base which contains a mixture of various salts, principally silver bromide (or chloride in some paper emulsions), with minor quantities of other materials, such as sensitizing dyes, iodides, and hardeners. The negative, as we have seen, is made up of a variable quantity of minute silver particles or "silver dust" suspended in this gelatin, following development.

As the emulsion and negative, respectively, always follow the foregoing description, it seems that there is very little opportunity for variation. Therefore, let us consider the variety of photographic characteristics which may be found among negatives, and from that determine the corresponding variety of emulsion characteristics. After all our interest in emulsions is limited strictly to the negative qualities which the emulsions will produce.

A negative, being an image made up of a variable deposit of silver dust suspended in gelatin, has two general characteristics: the amount of silver present in the entire negative, and the amount of silver in one area as compared with that in another area. In short, the negative has density and contrast—and that is about all. It has incidental color, but as the color gives it a longer or shorter printing time, color may be considered as a minor factor of density.

As we know, **density** is a product of exposure; **contrast** is a product of development. There are no other factors. Therefore, the logical deduction is that we need only one emulsion, and by the manipulation of ex-

posure and development use it universally. In fact, almost this identical condition was true for many years, and photographers did a highly creditable job with this "universal" emulsion.

However, we must now distinguish between **general density** and **specific density,** just as we must distinguish between **general contrast** and **specific contrast.** Thus we find that while holding a uniform general contrast, i.e., maintaining a constant gamma, there may be a wide variation in the specific contrast of the negative. In similar manner, while maintaining a constant exposure or a constant over-all density, there may be considerable variation in specific density.

The Emulsion Speed-Factor.

In breaking down these factors we find that some new factors must be taken into consideration. Of course, the first one is that of exposure. If we define exposure in two ways, we establish two factors which together constitute the true exposure: 1. Exposure is the submission of the emulsion to a sufficient quantity of light to produce the desired degree of reaction. 2. Exposure is the physical act of controlling the submission of the emulsion to light action so that the exposure is limited to the desired amount. Note that in both cases no mention is made of **time** or of **aperture;** rather the integrated value of both factors is taken as **amount.** True, a long exposure to weak light will not be just the same as a brief exposure to a strong light. But as far as we are concerned in practical photographic applications, we may ignore this factor and assume that one-thousandth of a candle of light will have the same action in one second that one candle would have in a thousandth of a second.

To introduce an unfamiliar term, we may say that an exposure of one second at an aperture of *f* 1 is a

total exposure of one **focal-second.** Here we have a unit of exposure **amount.** Obviously the focal-second is an exposure which would be used to photograph the proverbial black cat in a coal cellar with any modern emulsion; so we leave this as an existent but impractical standard unit, and for practical use we split it into one thousand parts, which we shall call **milli-focal-seconds.** We will then find that 0.9766 milli-focal-second (mfs) will have these values: 1/1024 at *f* 1; 1/500 at *f* 1.5; 1/256 at *f* 2; 1/128 at *f* 2.8; 1/50 at *f* 4.5; 1/32 at *f* 5.6; 1/16 at *f* 8; 1/8 at *f* 11; 1/4 at *f* 16; 1/2 at *f* 22 and 1 second at *f* 32. All these have the same exposure as far as **amount** is concerned.

Then, our two factors—the amount of light necessary and the exposure of the emulsion to this amount of light—taken together introduce the first of our basic factors. We find that the amount of light necessary is subject to wide variation. Some emulsions require much more light than others for a similar degree of reaction. Therefore the first factor will be based upon this difference, and as the difference is a result of the variation in degree of emulsion response, we simply call this the **sensitivity factor**—more widely known as the **emulsion speed-factor.**

The Factor of Specific Density.

The next factor is that of specific density. Suppose an original is prepared, half of which consists of a continuous tone and the other half of sharply defined black lines upon a white background. If we determine the specific sensitivities of a number of emulsions and make photographic copies of this original, giving each emulsion its exactly correct exposure, we find a variation in result. Some negatives will exhibit a smoothly flowing, evenly graded tone, but there will be an absence of sharp division in the black-and-white area.

Other negatives will show a brilliant and clean-cut black-and-white, but the continuous tone will be harsh, abrupt, and often non-uniform.

These characteristics are usually described as the "contrast" of the emulsion, and we speak of hard-working emulsions and soft-working emulsions; but let us see if this description is justified. You can develop a soft emulsion to a higher contrast than a hard one, yet the hard-working emulsion will have a superior "contrast," if we use the word only in regard to the black-and-white pattern. The factor which we encounter is that of specific density, in which comparatively little differences in original light intensities produce relatively great differences in negative density. That is, a white area will produce an intensely black negative deposit while dark gray areas will have no effect whatsoever during the same exposure.

Therefore in order to photograph copy that is purely black-and-white, we want an emulsion of high specific density characteristics, or one which is described as hard-working, contrasty, and so on. The so-called Process emulsion is characteristic of this type. On the contrary, where delicate tonal gradation and roundness are to be preserved, we want an emulsion in which the specific density is even more subdued than the original tonal scale. Such an emulsion is represented by the typical "portrait" or soft-working emulsion.

In a way it is unfortunate that specific density should represent a condition which is so commonly called "contrast," but this confusion must be charged to the fact that there is a whole family of factors grouped under this same name. It is true that a high specific density factor indicates a negative with a high over-all contrast, or a high gamma. At the same time it is unfortunate that the use of the term "contrast" in its most valuable sense is so often ignored—that is,

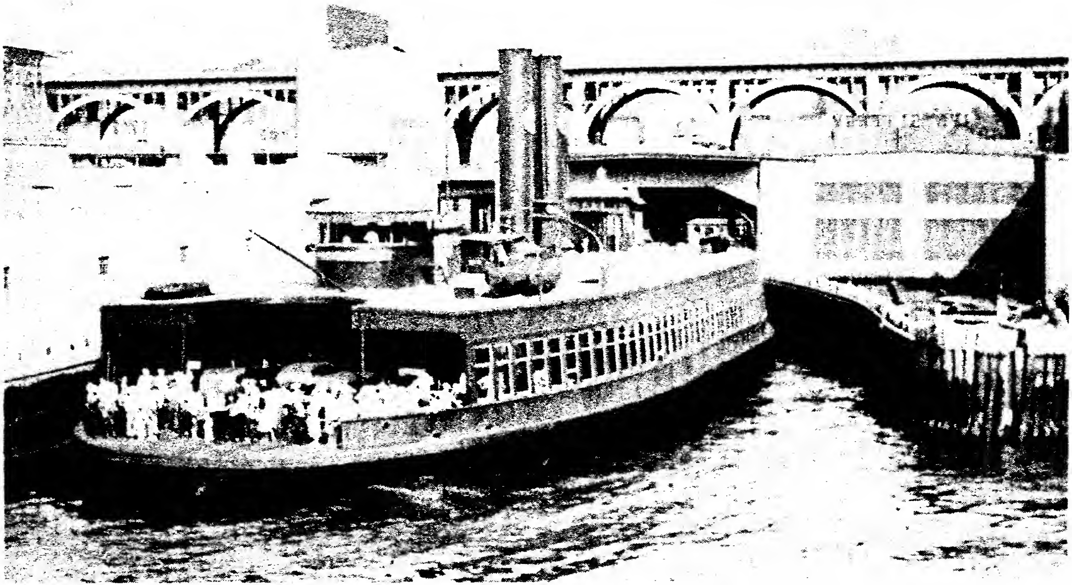

Fig. 158. Lack of ability to judge prints under a safelight may result in a poor picture, even if the negative is perfect.

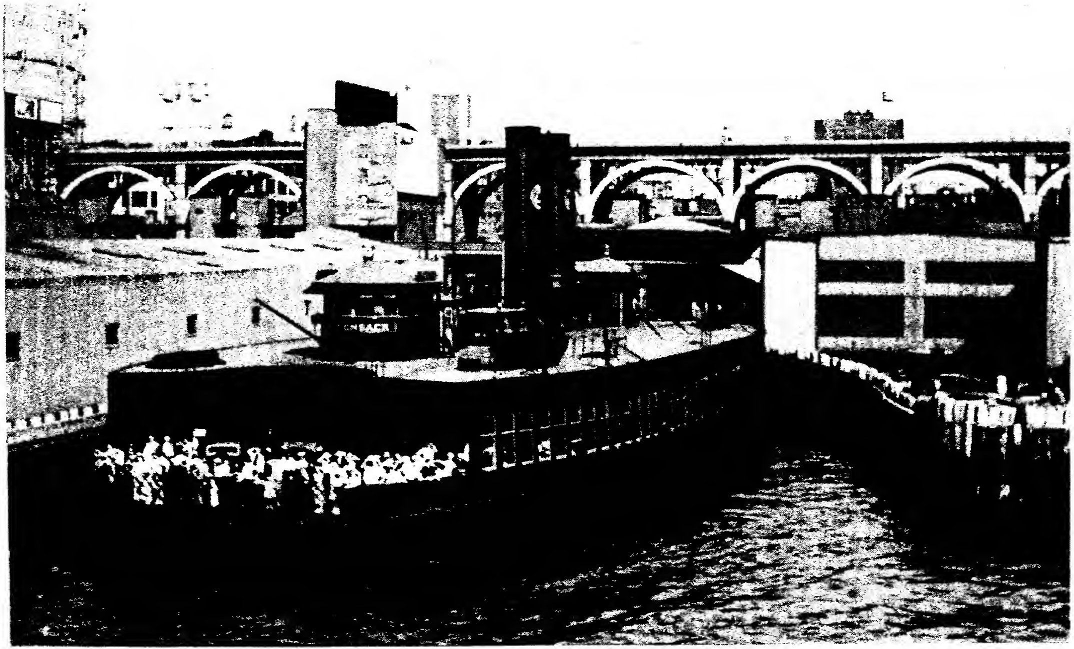

Fig. 159. A print given more exposure looked hopelessly burned up when viewed by safelight, but appears normal in daylight.

the specific difference in density between any two areas included within the negative.

Of course, it is easy to alter the difference to a slight degree by the time of development, but it is easier to make a much greater contrast difference in other ways. For example, if the original subject is black-and-white, the negative will show relatively great contrast, but if the original is made up of intermediate grays, then the negative will show a low contrast. The factor with which we are now concerned is that of specific contrast, and specific contrast more often results from changes in the original tonal scale than from any technical manipulation. Thus we have a contrast factor which precedes exposure and which is not a matter of technique at all.

However, we do not usually alter the tonal scale of an original by painting the units of the subject with contrasting paint, nor by clothing models in special costumes. This specific contrast is usually, but by no means always, obtained by a combination of controlled color response and careful lighting. The lighting is a matter of photographic skill, but the color response is strictly an emulsion characteristic, so we shall consider it.

A Conventionalized Art.

Photography is highly conventionalized. Photographs do not have a perfect resemblance to the original; but we become acquainted with "pictures" even before we learn to read, and learn that such-and-such an appearance in a photograph means so-and-so in the original. We honestly believe that photographs are highly faithful to the original. For example, the old, old, classic example—the sky! To becloud or not to becloud! What is the fact? The old-fashioned photographic sky was an empty white void. It changed

the entire character of any photograph just as certainly as shaving a man's head changes the whole appearance of his face. Yet it was accepted, and the appearance of even a slight sky tone indicated some lapse in technique!

Human vision is always experiencing color. True monochrome is so rare that it is almost non-existent in nature, yet we strive to reproduce color in monochrome with no loss of fidelity. It simply cannot be done! However, we do have emulsions which are highly sensitive to color, and, on the whole, results which are far from perfect are fully satisfactory from a practical point of view. Therefore, our specific contrast seems to depend upon lighting, color of original, and upon the control of the color.

Emulsions and Radiation.

Photography is a process whereby specific radiation produces a record through certain chemical reactions, which record bears a more or less striking resemblance to the original object or scene recorded. That the emulsion is sensitive to the same radiation which affects the eye is a coincidence. There is absolutely no relationship whatsoever between human vision and photography other than this chance reaction to a common radiation band. However, "color" as we see it is a mental response to varying wavelengths of radiation, and as the emulsion will respond in varying degree to a similar variation in wavelength, it is obvious that a certain resemblance will be inevitable.

Now we must review some facts which have been presented in earlier chapters of this book.

The original photographic emulsion was highly sensitive to radiation which does not affect the eye at all—namely, the ultraviolet. But this sensitivity extended down into the visible radiation, so that radia-

tion which produced the visual sensations of violet and blue would also affect the photographic emulsion. Before proceeding, let us take time to review briefly two factors which must now be considered.

In the first place, any radiation which will affect the emulsion will cause a change from sensitive silver salts to metallic silver dust. Thus any radiation which will affect the emulsion will produce an image or a density when the negative is developed; and consequently any radiation which will affect the emulsion will produce white or a light tone in the final positive print. We are accustomed to think that light, which is active, produces white, and instinctively we forget the negative-positive step and think that the active light produces no effect and shadows produce black. Often we unconsciously credit the negative with those characteristics which really belong to the positive. So, we must not forget that active light produces density in the negative. Conversely, inactive light or radiation produces no effect upon the negative, and the print is dark.

The Radiation Spectrum.

The second factor to be remembered is the radiation spectrum. This extends without known break from the long-wave radio radiation, in which each wave is several kilometers long, down to the cosmic ray whose wavelength is too short for rational conception. Between these two limits fall the short-wave radio, Hertzian radiation, infrared, visible light, ultraviolet, the various radiations of radium and X-rays, and the cosmic radiation. Among these we find photographically active radiation in the infrared, visible, ultraviolet, radium, X-ray, and perhaps in some cosmic radiation.

Thus the radiation spectrum runs straight along

from one extreme to the other. In short, it is lineai (Fig. 1, Chapter I). Visible radiation extends approximately from about 740 millimicrons in the deep red to about 380 millimicrons in the violet. However, this linear visible spectrum is subjected to psychological distortion, so that the sensory visible spectrum is circular, with the non-spectral purples filling the gap between the red and the blue-violet.

The original emulsion was sensitive to radiation between about 480 and 300 millimicrons, or to a good portion of the ultraviolet, to visible violet, and to blue. The result was that photographs made upon such an emulsion reproduced all blues and violets in a much lighter tone than was natural, while all other colors were reproduced in a tone much darker than was natural. In short, the blue sky reproduced as pure, glaring white against which white clouds were necessarily invisible.

Research slowly extended the sensitivity into the blue-green and the green. Then a yellow glass was placed over the lens. Of course this glass absorbed a part of the blue and transmitted all the green and red, so that the blue action was slowed down sufficiently to give the green time to act. This caused a lightening of greens and a darkening of blues. The sky took on a tone against which the white clouds were visible—and the yellow glass became known as a "sky filter."

We have spoken almost synonymously of yellow and green. There is a good reason for this, and one which the photographer must never forget. Yellow is a mixture of green and red, and has no independent existence! Yellow is the opposite or complement of blue. Therefore, if an emulsion is sensitive to blue and to green we may expect the following: The yellow will obstruct or absorb blue, making its action less and thus lightening the negative deposit. The yellow will

not obstruct either the real green or the green component of yellow, so that both yellow and green will have time to make an impression during the exposure for the blue, which has been extended by the holding-back property of the yellow filter.

The colors of nature are largely made up of greens and yellows. Even the reds which exist (with the exception of a few pure red flowers) have a considerable mixture of other colors, while the foliage greens, bark greens, browns, tans, duns, and other natural colors have a lot of green and yellow. Obviously then, when the emulsion sensitivity was extended to include the green, the color balance of outdoor shots was enhanced. It was only a matter of time to extend the sensitivity to the point where it not only included the full range of visible red, but went beyond it to include a considerable range of the radiation below the visible red, which is known as the infrared.

Selecting an Emulsion.

Today emulsions are available which are sensitive to almost any radiation desired, from 1200 in the infrared to about 250 in the ultraviolet. Our greatest concern lies with the visible radiation which, as we have said, extends approximately from 380 in the violet to 740 in the red; and we say "approximately," because the actual limits vary with individuals.

Now assume that we have a white card upon which are mounted squares of blue, yellow, green, red, and black. It is possible for us to control the specific contrast almost at will by the selective choice of emulsion and filter. The table on the opposite page shows how different colors are rendered in monochrome by various film and filter combinations.

It must be remembered, too, that there are varieties within each of the three types of films. Some pan-

Emulsion	Filter	White	Blue	Yellow	Green	Red	Black
Color-blind	None	White	White	Black	Black	Black	Black
Ortho	None	White	Light	Medium	Dark	Black	Black
Ortho	Yellow	White	Medium	Light	Medium	Black	Black
Pan	None	White	Medium	Light	Medium	Dark	Black
Pan	Blue	White	White	Black	Black	Black	Black
Pan	Yellow	White	Light	White	Medium	Dark	Black
Pan	Blue-green	White	Light	Medium	Medium	Black	Black
Pan	Red	White	Black	Dark	Black	White	Black

chromatic emulsions are highly sensitive to red and hardly sensitive at all to green; the color sensitivity of others closely parallels the visual brilliance of all colors. Some ortho emulsions fall off rapidly in the green and others are highly green-sensitive. Therefore, it is essential that the photographer become familiar with the meaning of the response curves of the emulsions, a subject which has already been fully discussed (see Fig. 119, Chapter IX). We find that the specific sensitivity of the various emulsions is largely a matter of color response, to which must be added the inherent contrast characteristic of the emulsion itself and the development which it receives.

There is one other factor which is intermediate between the specific density and the specific contrast. This is the resolving power of the emulsion, or the degree of sharpness of the edge of a line as reproduced. In effect this means the degree to which the emulsion will separate or "resolve" extremely fine lines placed very close to one another.

In selecting an emulsion for any purpose we shall have to consider:

1. The emulsion sensitivity, which determines total exposure.

2. Inherent contrast factor of the emulsion.

3. The color sensitivity or spectral response of the emulsion.

4. The resolving power of the emulsion.

When the emulsion has been exposed, we must

take into consideration the degree of development which will reproduce the specific density and the specific contrast desired. That is the whole story.

Now for a few generalities, which are subject to the exceptions which modify most generalities:

1. As a rule an emulsion of high resolving power has high inherent contrast and low sensitivity (slow speed).

2. As a rule a slow emulsion is finer grained than a fast one.

3. As a rule a slow emulsion requires less development than a fast one.

4. As a rule increased development will increase contrast in the negative, but will not favorably affect shadow detail.

5. As a rule overexposure will nullify action of the filter.

With these things in mind, let us first seek the universal emulsion. It is true that by a judicious use of filters with an orthopanchromatic film (or visual curve panchromatic), the results of either color-blind or orthochromatic emulsions can be reproduced, but this does not mean that **any** panchromatic emulsion can thus be made to duplicate the results of **any** color-blind or ortho emulsion simply by filtering it. Inherent contrast, resolving power, and specific color response must all be considered.

Thus if a color-blind emulsion is to be imitated, the panchromatic emulsion need not be green-sensitive, but it must be of high inherent contrast because a blue filter tends to reduce the contrast of a panchromatic image. If the effect of a high-green ortho is to be imitated, a low-red panchromatic with a high-green response is necessary to start with, and a minus-red filter used. Thus instead of "imitating" other emulsions, one is really exercising selective control of the colors to be used.

Emulsions for Specific Uses.

And now as to specific emulsions. For printed matter and other originals which consist only of black-and-white, the emulsion should be slow, hard, and may be color-blind. Process films, positive stock, and lantern plates are of this type.

For copy work which includes continuous tones and colored originals, an emulsion similar to the foregoing is required, but it should be capable of lowered contrast and be fully color-sensitive. Panchromatic process emulsions are of this type; among the best are the 35 mm emulsions made for biblio photography.

For ordinary still-life photography, particularly indoors, a comparatively slow, orthochromatic emulsion is good. It has enough contrast to provide "snap," and sufficient resolving power to produce a crisp image.

If the still life includes furniture or other similar surfaces and colors which range into browns, a commercial panchromatic emulsion should be used, filtered if necessary to exaggerate the grain pattern in the wood. Be careful in using filters for interiors where colored patterns are found in rugs. The wrong filter will alter the entire appearance of the room by changing the rug color balance.

Silverware and glassware call for an emulsion which has sufficient contrast; you will want to subdue the sharp reflections from the subject, and it is desirable to have a suitable surface for the handwork which may be necessary later. However, unless the glass is colored, the color problem will not be serious. Therefore, use a relatively slow, fine-grained emulsion of moderate to high contrast, and one which has a matte surface (or better yet a double matte surface—matte on both sides). Make sure that it has a non-halation backing to hold down spreading highlights. Here are two factors, the matte surface and the non-halation

Fig. 160. Catalpa blossoms appear more like bunches of cotton in light print from a negative which was not critically sharp.

Fig. 161. Despite the lack of sharpness, this darker print gives a better suggestion of the true texture of the flowers.

backing, which are not emulsion characteristics at all, but which make the use of the emulsion easier.

When the photograph includes human beings there is that age-old argument of panchromatic vs. orthochromatic. Among portrait photographers this argument is still fought with great bitterness. Some portrait men say it is impossible to make a good portrait on panchromatic film, while the pan users say the other side is made up of a lot of old fogies. What is the truth?

The modern use of color has proven that the black-and-white photograph is dead, and except when it is used for making a monochrome study of pictorial value, it cannot compare with color. For years we have used an exaggerated contrast to make up for the loss of color contrast. The one-time popular portrait wasn't so much a likeness as a pleasing caricature of exaggerated vividness. If this is the type of portrait you wish to make (the term "portrait" as used here includes any and all photographs in which human faces predominate), then you will find the easiest way out is to use ortho. If you do this, however, watch out for the black lips and hollow cheeks which even moderate makeup will provide. You must also expect even the most delicate freckles to appear as ink spots. The ortho-portrait school also contends that no portrait negative is ready for printing until it has received a weight of pencil strokes at least equal to the original weight of the silver, so black lips and freckles mean nothing to them. These will be remedied by knife and pencil.

If you want smooth skin tones, lips which appear natural, and a general appearance of healthful normality, try pan film. If you want to add to the theatrical effect, don't wait to do your retouching upon the negative; do it upon the model. A suggestion of theatrical makeup will bring out all the vividness desired, and do

it much more naturally than will the ortho emulsion, which darkens every shade and tint of red or brown. I prefer the pan emulsion for photographing human beings, and by the same token I personally prefer that even professional studio portraits be unretouched. Almost the first stroke of the pencil takes away the spark of life and leaves behind only a wax model. Spotting and a very little lightening of deep shadows are about all that is possible without "killing" the subject.

Now let's consider flowers and other delicate textures. The colors will usually call for a pan emulsion. Microscopic resolving power isn't necessary, but smoothly flowing tones are. Therefore, choose a good orthopanchromatic emulsion. Use the filter which will best preserve the delicacy of the petals, usually a light filter of the flower's own color if it is vivid, or no filter at all for delicate flowers. The exposure must be full to bite into the deeper shadows, and development must be reduced to avoid clogging the fine texture.

For general landscape work the ortho emulsion may be used for spring and summer foliage, but in autumn or winter, or if there are flowers or human beings included, it is best to use pan. A yellow-green filter (or deep yellow or pale orange) will often help a lot in providing a slightly exaggerated color accent.

Emulsions for General Use.

For general all-around use, for souvenir shots, the "chrome" type of ortho films may be used because of their lower cost, but the red tones will be lost. However, this film is a lot better than the super-super-extra type of film. The ultra high-speed film is probably the worst emulsion available for anything other than those shots which (a) must be made at very high speeds (closeups of races and sporting events), and (b) those subjects the illumination of which is extremely poor.

High-speed film is a special film for a special purpose, and in fulfilling this purpose you must make certain sacrifices. You lose gradation, resolving power, quality in general, and get larger grain.

There is one type of emulsion, however, which will serve about ninety-eight per cent of all amateur purposes. This is the moderate-speed orthopanchromatic type of film which has a Weston rating of about 80. It is plenty fast enough for any work except the extreme, has full gradation and quality, has fine enough grain for big blowups, visual color response (approximately), and is suitable for all types of filter work. You can develop it to a high or a low gamma; you can lower its contrast with a blue filter or increase it with a red one. In short, you can do about as you please with it.

In my own work, aside from copying and photomicrography, I use this type of emulsion in 35 mm cameras, in larger rolls, and in sheet film for both commercial and portrait work. Remember that if you stick to one emulsion, you will learn to handle it better than you could ever handle a number of different ones.

Retain Your Individuality.

During the course of this discussion of the photographic negative a great deal has been said. I sincerely hope that a good portion has been of practical value to every reader. There have been times when some remarks have appeared to be tinged with animosity toward certain processes. At other times there may seem to have been undue value placed upon certain items. In fact, such personal bias has been kept at a minimum. Naturally, even the most sincere opinions of any individual are colored by his beliefs. But it may be added that the experimenter makes an honest effort to base his opinions upon experimental evidence, not

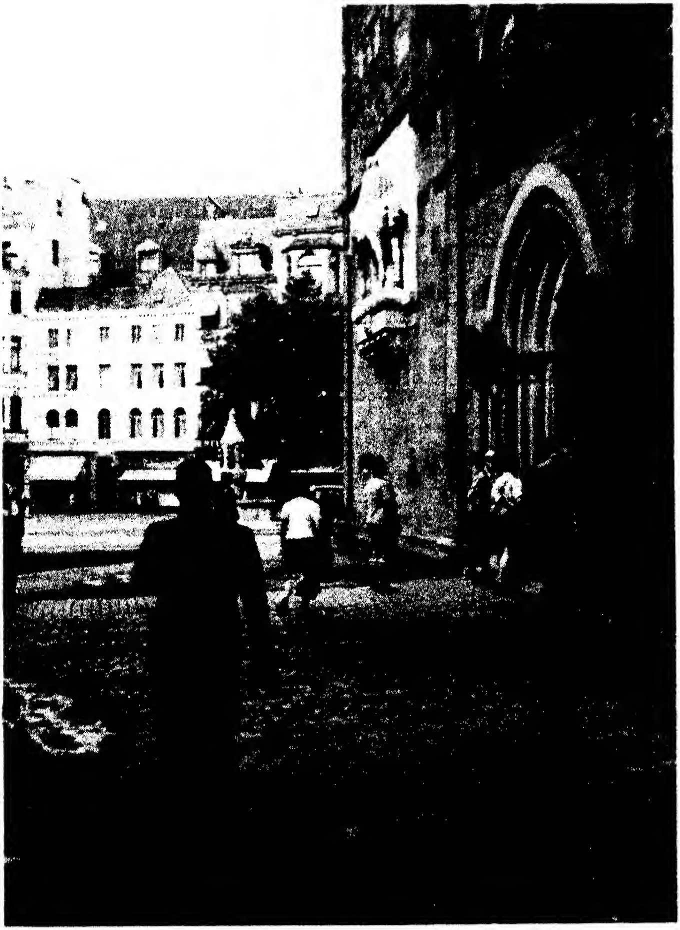

Fig. 162. Most amateurs make prints from the full negative, as was done here, instead of eliminating unwanted portions.

the evidence of one or two trials, but of repeated tests in which the average of all results is taken as indicative of the truth.

There is a strong tendency in amateur photography to wander far away from fundamental truths. The eventual result is a morass of fancy, superstition, and even mysticism. We can become lost in a sea of secret formulas and processes for which the most fantastic claims are made, but few of which have any foundation in truth. Very often such claims are bolstered by "tests" which are designed, not to show the truth, but to emphasize the claims made for the secret product. These tests are convincing; but the amateur who knows how to conduct a fair test will soon see through the fallacy.

On the other hand, the nature of human progress is such that from time to time new ideas will be developed. Many of these ideas are of considerable value. There is no touchstone for easy proof, and the amateur is advised to try everything which appeals to his imagination, but to try it with no bias one way or the other. If careful tests prove the product to be good, then it should be adopted. If it proves bad, then it is discarded. That is so simple it hardly needs statement. However, the great factor is not to permit prejudices for or against to be formed. I have tried to be absolutely impartial, to recommend things which have been proven good in my laboratory, and to warn against some of the things which tests have proven to be largely ballyhoo. However, in every case I have tried to give you a basis for making your own tests and forming your own judgments.

There are just two points to be called again to your attention, and upon these depends your success or failure in all photography—not in negative making alone. First, insist upon retaining your individuality, your right to test, examine, and judge for yourself,

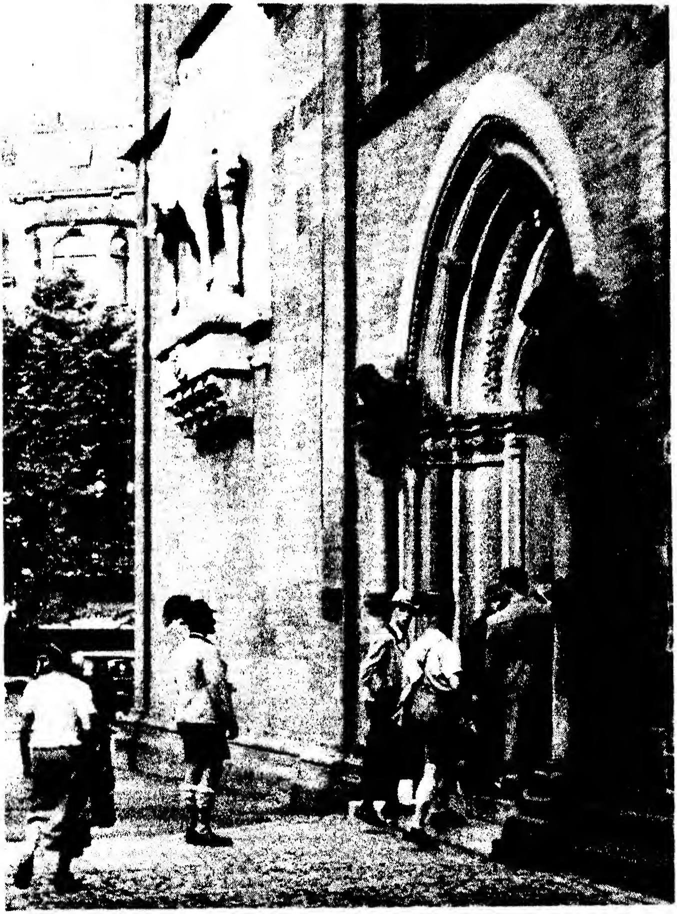

Fig. 163. A more pleasing result was obtained in this print, made from a selected portion of the same negative used in Fig. 162.

your right to photograph the subjects which interest you, and to develop your film in coffee if the mood seizes you. In short, the successful photographer is the individualistic photographer. The copier, the imitator, has never yet achieved outstanding success in any field of art.

Second, never believe or disbelieve anything until you have tried it for yourself. Deliberately make all the mistakes you can think of, keep data, and keep the negatives. Only in this way can you really become a master of photography. No theoretical knowledge has much value until it has been put into practical use. This is as true of wrong as of right procedure. Never be guilty of saying "I wonder what would happen if I did so and so?" Instead, as soon as the idea strikes you, try it and see! The result may possibly be a failure, but from just this kind of experiments have come some of the most valuable discoveries. You will probably not carry out what you first expected to do, but you may do something else. And in case of total failure your curiosity is satisfied and you will have learned another thing which you **know** you must not do.

The negative is important. It is not, however, all-important. Photography is divided into three phases. First there is the camera, its accessories, light, optics, and all the factors which make image formation possible. Therefore it might be said that while negative making has to do with recording the image, it must be preceded by the formation of the image. These two steps are pure craft, but not at all mechanical, as we are so often told.

Following the negative comes the production of the positive. This, we are told, is the purely aesthetic side of photography—which again is not correct. There is much of that element, it is true, but there is just as much technical procedure in print making as in negative making. The amateur should not overlook

this important phase as a field for further study and experimentation.

Up to this point we have given our entire attention to the production of a photographic negative that approaches perfection. We have investigated the emulsion, developing agents, formulas, processing techniques, density, contrast—in short, every factor that plays a part from the time the film is bought until the negative is ready to be printed.

In our attempt to produce the best possible negative, however, we must not lose sight of the fact that, after all, the negative is not the finished product in the photographic process. It is only a tool that is used to produce the finished picture; and the picture is our ultimate goal. This means that knowing how to use the negative is just as important as knowing how to make it. Unfortunately, a perfect negative can produce a very poor print if not handled properly.

When making and using negatives, then, let's not lose sight of the fact that it's the final picture that counts. First, consider the subject (Fig. 157), lighting, and camera angle. Next, exposure. Then when the time comes to make the print, remember print quality (Figs. 158 to 161). Perhaps the full negative will not produce the most pleasing picture, so be sure to use only the desired portion (Figs. 162 and 163). Use the grade of paper that gives the best contrast range. And, finally, if special control is required, such as dodging, burning in, or correction of distortion, make use of these measures in the interest of a good picture.

In addition to acquiring skill in developing, the amateur photographer must learn how to criticize his work. This means that he must be able to recognize faults in the negatives, know what caused them, and learn how to avoid them in the future. Because of its importance, the next and final chapter will be devoted entirely to this subject.

XII

NEGATIVE FAULTS

XII.

Negative Faults

THE negative is the keystone of all photographic construction. You have considered the routine of making the negative; you have considered the characteristics of the negative; you have learned to read the negative; and you have learned the important factors concerning the technical characteristics of the image.

In spite of this, however, you will continue to make negatives which will not produce good prints—we all do this. For your own peace of mind, remember that the photographer who never makes a poor negative is in the same class with those other two mythical beings, the man who never makes a mistake and the one who never told a lie!

If you make ten thousand negatives, you will find that you can also make ten thousand mistakes. Fortunately many of them are not serious. As you progress you will make fewer and fewer serious errors, but you will probably never make a negative which

you consider perfect. You will also find that those negative faults which are so serious as to make a good print impossible fall naturally into two groupings. The first classifies these faults according to the physical appearance of the negative—that is, scratches, spots, stains, and other blemishes. The second natural grouping considers the origin of the fault—that is, whether it happened before the exposure, during exposure, during development, and so on.

While the first series is the more natural for general discussion, it is open to objection in that it does not emphasize the connection between cause and result. Therefore, at the cost of repetition, we shall discuss not only the negative faults, but the causes which result in such faults; and we shall do this in the normal order of handling the film.

1. To simplify the interrelation, we refer to the chart, Fig. 164, which illustrates the different faults in their mutual relation to the direct causes. In this chart the six generic groups of faults are shown in the center column. At each side are the direct causes grouped under headings arranged in proper order. To prevent confusion among the crisscrossed guide lines, each generic group of faults has its own characteristic line—dotted, dashed, dot-dash, etc.

Supplementing this is the Synoptic Key on the following page. In using it, the negative should be placed before you and supported so that sufficient light is transmitted by it to make all its details clearly visible. Starting with **Key Group 1**, give your attention to nothing but the density of the image. If the density is satisfactory you will at once turn to **Key Group 3**, as indicated by the numeral "3." **Key Group 2** is ignored because this is used only if the density is unsatisfactory. Turning to **Key Group 3** you examine the negative for contrast only. The contrast may be too high, so you pass on to **Key Group 4**. Under

subhead (**a**) you find not "high contrast," but the actual image faults which are characteristic of high contrast. You find that the cause is overdevelopment, and the number in parenthesis refers to the paragraph number in this chapter. Turning to this paragraph (or paragraphs) you find a more detailed discussion of high contrast, not only that produced by overdevelopment, but by other causes as well.

You may have a negative which displays some strange spots, so you are tempted to turn at once to the Key Group which concerns spots (6). However, until you master the identification of faults, you will do better to take each negative through the entire Key. When you have done this a few times you will realize that some faults are related to others in a way which you probably did not suspect.

A study of your negatives in relation to the chart and to the Key will soon convince you that good negative making is not a matter of guarding against a number of separate errors, but of developing a routine which automatically guards against such errors at every step in the process. Now let's consider the general subject of negative making.

Faults Originating Before Exposure.

2. Precautions against negative failures begin some time before the actual exposure is made. The initial precaution—developing an unexposed film from each new batch to determine the degree of inherent fog—is usually neglected for good reason. Fortunately, modern films are so uniform that this precaution is really unnecessary.

3. Most of the faults for which the manufacturer is blamed should be laid at the door of either the dealer or consumer. Film is extremely delicate and must remain so if it is to have value. The first pre-

TROUBLE-SHOOTING CHART LOCATES SOURCE OF COMMON NEGATIVE FAULTS

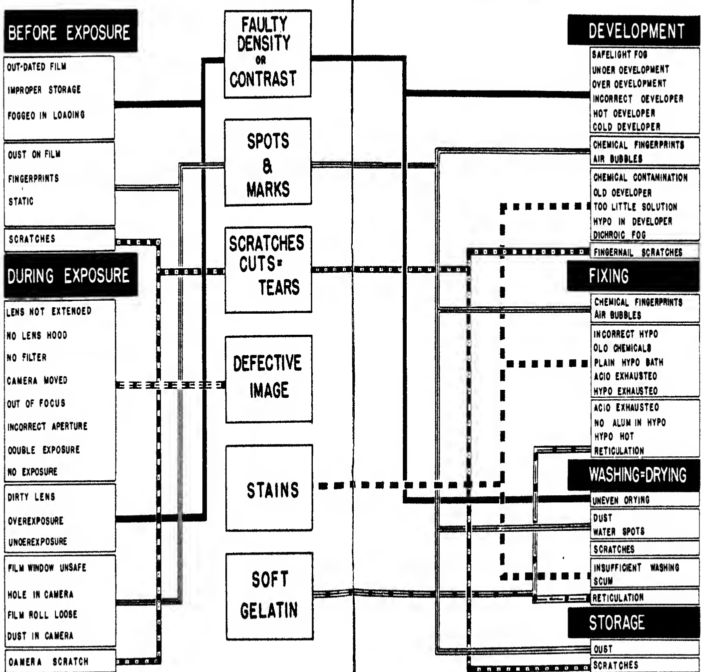

Fig. 164. This chart will help you determine where, in the course of handling, the quality of the negative may become impaired.

The six generic groups of faults are shown in the center column; guide lines indicate the possible causes of each.

SYNOPTIC KEY TO NEGATIVE FAULTS

The proper use of this table is explained fully at the beginning of the chapter, Section 1

1. Negative shows normal density throughout .... **See No. 3**

2. Density of negative not satisfactory:

a. Mottled pattern in plain areas	Old film, damp storage	(3-5)
b. Image light with transparent shadows	Underexposure	(20)
c. Image heavy, black throughout	Overexposure	(20)
d. One area lighter than another	Uneven drying	(61)
	Uneven development	(40)
	Uneven fixing	(40)
e. Lack of uniformity	Insufficient solution	(34)
f. Light central portion	Films stuck together	(44)
g. Irregular light spots	Oily film	(9)

3. Contrast of image normal .... **See No. 5**

4. Contrast too great or too slight:

a. Excessive density in highlights; shadows thin, transparent	Overdevelopment	(28)
b. Highlights and shadows gray	Underdevelopment	(28)
	Dust on lens	(21)
c. Highlights normal to heavy; shadows gray; gradation degraded; image veiled throughout	General light fog	(25)
	General chemical fog	(3)
	No lens hood used	(11)
	Poor safelight	(25)
	Exhausted developer	(33)
	Bad storage conditions	(3)
	Old film	(3)

5. Film shows no spots or marks .... **See No. 7**

6. Film shows spots or marks—clear, white, gray, or black:

a. Irregular shape, small to medium in size.	Dust on film surface .... (6)
b. Minute, round clear spots	Pinholes .... (42)
c. Spots round, transparent, or lighter than image	Air bubbles in developer .... (43)
d. Spots round, yellow turning black	Air bubbles in hypo .... (43)
e. Sharp-edge "splash" spots, dark to black	Developer splashed on film .... (39)
f. Same as (e) transparent	Hypo splashed on film .... (39)
g. Small black spots often with one or more "tails"	Chemical dust on film .... (30)
h. Round spot ¼ to ½ inch diameter, may be extended to oval or round-end bar..	Unsafe film window .... (23)
i. Round to pear-shape spots, lighter or darker, or with dark edge and light center	Water spots, uneven drying .... (58)
j. Small spots indented in gelatin; pit marks	Excessive alum in hypo .... (45)
k. Thin wavy traces	Lint .... (6)
l. Irregular, gray, branched or forked lines.	Static .... (7)
m. Irregular spots in series of curved lines..	Fingerprints .... (9-29)
n. Gray or black marks, fan to wedge shaped	Pinhole in bellows or camera .... (24)
o. Gray or black curved marks running into film from edge	Film roll loose .... (4-5)
p. Fine, black, short lines intermingled all over film	Reticulation .... (53)
q. Streaks running away from highlight areas	Lack of agitation .... (35)
r. Streaks from one edge of film	Dirty racks, tanks, or tray .... (36)
s. Mottled film	Exhausted developer .... (33)
	Insufficient developer .... (34)
	No agitation .... (35)

(Continued on next page)

(Continued from preceding page)

t. Transparent, soft-edged regular shape...	Finger or other object in front of lens during exposure ....(14)

7. Film free from mechanical damage......................... See No. 9

8. Film shows mechanical damage, scratches, tears, etc.:

a. Broad, irregular scratch with torn edges.	Fingernail scratch ....(37)
b. Emulsion loose at edge, blistered and torn	High temperature ....(27) Plain hypo ....(51)
c. Tear, usually triangular................	Gouge from film corner ....(52)
d. Fine hairline, parallel to film edge, over several frames of film...............	Cassette or camera scratch ....(22)
e. Short hairlines, parallel to film edge.....	Dust scratches ....(6)
f. Short hairlines, straight or curved, any direction	Scratches from enlarger ....(65)
g. Hairlines parallel to film edge, appearing after film is dry.....................	Keeping negatives in roll...........(64)
h. Straight or curved hairline along length of film but not exactly parallel with edge	Sponge scratches ....(58) Polishing scratches ....(63)

9. Image clear, sharp, well defined throughout.................. See No. 11

10. Image defective in some respect:

a. No image on film......................	No exposure made ....(14) Fixed before development ....(14)
b. Image on part of film.................	Obstacle in camera ....(14-16) Not enough developer ....(41)
c. One part of image darker than another with sharp line of division............	Non-uniform developing ....(40) Irregular tank filling ....(40)
d. Image a blurred circle in center of film..	Lens not extended ....(13)

e. **Image all or part positive**	Reversal or solarization	(25)
f. **Image thin; irregular fog**	No lens hood used	(11)
g. **Sky heavy, dense; color values incorrect.**	No filter used	(12)
h. **Image blurred throughout, definite double outline**	Camera moved	(18)
i. **Image blurred throughout, no double outline**	Lens not focused	(17)
j. **Background sharp, moving subject blurred lineally**	Shutter speed too slow	(17)
k. **Part of subject sharp, other parts blurred**	Lens aperture too large	(17)
l. **Subject and background equally sharp, no separation of planes**	Lens aperture too small	(19)
m. **Center sharp, corners not sharp, or vice versa**	Film bulged into camera	(18)
n. **Two or more different images on film**	Double or multiple exposure	(15)

11. Film shows no discoloration of any kind .... **See No. 13**

12. Spots, areas or entire film discolored:

a. **Frosty, crystalline deposit**	Hypo remaining in film	(46)
b. **White, powdery deposit**	Acid exhausted from hypo	(31-47)
c. **Opalescent white appearance**	Incomplete fixing	(50)
	Too rapid drying	(62)
	Dried in alcohol	(62)
	Precipitated sulfur	(48)
d. **Silvery scum on film**	Dirty trays and tanks	(36)
e. **Greenish white stain**	Chrome alum stain	(49)
f. **Dirty scum on film**	Oil and dust on surface of developer, or other solution	(57)
g. **Colorless slime on film**	Tanks not clean	(36)
h. **Purple spots**	Chemical dust	(30)
i. **Purple stains**	Films stuck together in hypo	(44)

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j. **Blue-green stain**	Warm chrome alum solution	(49)
k. **Clear blue spots and stains**	Iron in solution	(30)
l. **Yellow to brown stains**	Oxidation stains	(33)
	Alkaline hypo or old hypo	(47)
	Old developer	(33)
	Too little developer	(34)
	Insufficient sulfite	(26)
	Too much carbonate	(26)
	No stop or rinse bath	(42)
	Not immersed in hypo	(47)
m. **Pink stain, green by reflected light**	Hypo, etc., in developer	(38)
n. **Yellow to brown stain after negative is dry; fading**	Insufficient washing-fixing	(55)

13. Negative surface hard and firm while wet....................See No. 15

14. Negative surface soft while wet:

a. **Surface "slick" and slippery**	Soft to danger point	(52)
b. **Emulsion leaves base at edge**	Frilling	(52)
c. **Emulsion leaves base in mid area**	Blisters	(52)
d. **Emulsion leaves base entirely**	Melting of emulsion	(59)
e. **Emulsion tears and a part leaves the base**	Emulsion tear	(52)
f. **Emulsion finely roughened; dries with network of fine lines: surface dries quickly while still wet beneath**	Reticulation	(53)

All of the troubles listed under item 14 are due primarily to solutions at too high a temperature aggravated by the use of plain hypo or a hardening bath which has become exhausted.

15. If your negative has passed all the tests and you have arrived at this point without having checked any item or items listed under the even numbers, you may regard your negative as perfect for all practical purposes.

caution is to note the so-called expiration date on the package. As a rule this date is one year in advance of the date of manufacture, and if film is kept in good storage it is usually good for another year after the expiration of the time indicated. The possible life of an emulsion seems to increase as the sensitivity decreases. I have had success in using process plates which were five years past the expiration date.

On the contrary, film will often be found in bad condition even before the expiration date. This is caused by bad storage conditions. Dampness is to be avoided as it will hasten the fogging and mottling of the emulsion. Storage in a room where there are gas burners or appliances is to invite speedy fog. High temperature is also very bad, but its effects are increased by dampness. In the kitchen darkroom of a heated apartment, with gas stove and the steam from dishwashing, the three enemies of storage are found concentrated. Do not expect emulsions to keep well under such conditions.

Noting the precaution to keep films cool, many amateurs put them in the refrigerator. This is a mistake unless the box is one of the type which completely dehumidifies the air. It is best to keep films in a place where the temperature is reasonably low, where the air is dry, and where there are no gas appliances. The warning against gas also applies to neighborhoods where chemical fumes are encountered.

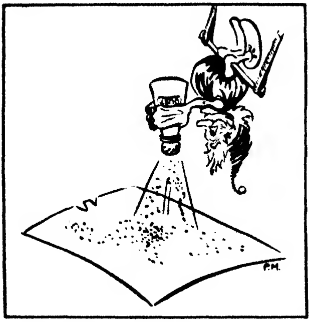
4. Although the amateur takes every precaution when developing his film, he is often careless in loading the camera, film magazine, or filmholders. There is no good reason or excuse for using any kind of light in loading sheet film, 35 mm film, and other unprotected material. But because stray light is so hard to guard against, it is suggested that the changing bag be used as routine for loading sheet film, and that a magazine loader be used for loading 35 mm bulk

film into the magazines. Of course, factory-loaded magazines and rollfilms need no such precautions.

However, the rollfilm suffers largely from one kind of carelessness, that of allowing the roll to unwind while loading it into the camera. If you have any trouble at all in keeping the roll wound tightly when loading, make a practice of inserting the roll in the camera with the seal unbroken. Then break the seal and pull out enough paper to reach the takeup spool, allowing the camera spring to hold the roll firm. Likewise, seal the exposed roll before removing it from the camera. This procedure may prove awkward at first, but it soon becomes easy and will save many a film which otherwise might exhibit edge fog.

5. Film which is old starts to fog from the edges toward the center, eventually becoming completely fogged. Dampness usually produces a mottling similar to a fine tortoise-shell pattern. Gas accelerates the aging effect. Edge fog from a loose roll is differentiated from fog produced by age, because the fog is deepest near one end of the roll, recurring at somewhat uniform but decreasing intervals, and usually has a more distinct edge than does the latter. Age fog is usually more or less uniform around all edges, while edge fog is usually much heavier on one side of the film. In fact it is often confined to one edge of the film.

6. Other faults originating before exposure are due largely to carelessness of technique. Dust is not usually regarded as a result of carelessness, but more than a minimum amount has no other excuse. Dust may not always cause scratches, but dust on the film at the time of exposure will cause a transparent (unexposed) spot or pinhole, and if composed of some substance like mica it may produce tiny fog flares due to reflection. When lint covers the film, the marks are



Protect your negatives from dust. It will cause trouble!

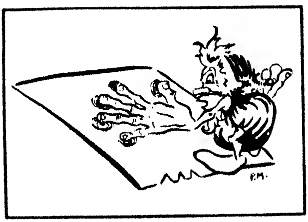
fine, wavy lines. These transparent spots on the negative are responsible for black spots and "wigglers" on the print. Of course we must remember that by far the greatest trouble comes from dust collected by the film while drying, or that settles on the dry film during enlargement. These dust particles cause white marks on the print. However, as specks and lint particles are easily recognized, we need say no more about dust as the original cause of spots. It simply should be guarded against by keeping the camera clean and by avoiding dirt as much as possible in all darkroom operations.

7. Static marks, instead of being fine, sharply defined lines, are usually gray, have an appreciable width, and have blended edges. Examination under a microscope shows a great difference between static and scratches. Static is an exposure to light, while scratches are mechanical defects. Static is difficult to describe; the marks are usually but not always faint, and their shape is strongly suggestive of the photograph of a bolt of lightning. The static line is an image formed by light and its greatest density will rarely exceed the maximum density of the image. Scratches usually appear fully opaque, or if large, fully transparent with opaque side bands.

8. Among these defects should also be mentioned abrasion marks. Pressure upon a film, especially with a sharp point or edge, will result in a mark. Usually there is a slight mechanical depression. Scratches par-

allel to the edge of the roll can be caused by slight nicks on the frame which forms the picture plane in the camera (see ¶ 22). A scratch which cuts through to the film base will show a broad black line on both sides of the scratch, which is an exaggerated abrasion mark. While these do occur, they are not common enough to be a source of serious danger, although there was a time when they were plentiful. Modern emulsions do not seem to be as susceptible to pressure as they once were.

9. In loading sheet film particularly, there is grave danger of fingerprints. Many people have skins which are naturally oily, and in a warm darkroom they may perspire. A moist or oily finger pressed upon the film will give it a protective coating which will subsequently prevent developer action, and a fingerprint which will print dark is the result. It is not difficult to learn to handle sheet film by the edges. Some individuals, on the contrary, have dry skins, and it is not at all unusual to find amateurs who can handle their films freely without ever leaving a mark or fingerprint upon them.



Avoid fingerprints. Handle the film by its edges only.

These constitute the most important causes of failure which are encountered before the exposure is made. No mention has been made of a remedy in any case, simply because there is no remedy other than that which may be applied to the print in the direction of print retouching. We shall not consider the subject of negative retouching, as it is rarely practical upon the small negatives which are so often used for amateur photography.

Faults Originating During Exposure.

The faults which originate during exposure may be caused by incorrect camera handling, by incorrect camera adjustment, by optical interference, or by some factor which affects the photographic characteristics of the negative. In fact, these errors of exposure are often ignored in such a discussion as this, with the argument that they are not negative failures, but failures of technique. This seems to be drawing an extremely fine distinction, and there is no reason for restricting faults to chemical, optical or mechanical ones. We shall try to include everything which may be considered a fault and which is in any way revealed in the negative.

There are three principal subgroups. First we have those faults originating in faulty technique; second, those which are caused by faulty exposure; and third, those which are directly due to failure of the apparatus, or its handling at times other than the actual exposure.

10. The camera as a picture-making apparatus actually is not complete until equipped with those accessories which add to the quality of the finished picture—lens hood, filters, tripod, and so forth.

11. The lens hood is a device which limits the light admitted into the camera to that which actually makes the image. It is useful at all times, of great value in all outdoor work, and indispensable when shooting against the source of light. An outdoor backlighted exposure made without the hood usually has the principal subject reproduced in dull gray with no brilliance and not much detail. Halation is often strong, and the entire negative is veiled with a more or less uniform fog. The lens hood will usually permit such exposures to be made while retaining the brilliance and crispness of the more ordinary lighting.

12. The use of a filter, or failure to use one, is perhaps more a matter of personal choice than a true fault; however, there seems little reason why a fully opaque sky should not be counted an error in landscape photography. Therefore, while slight differences of opinion are certainly to be tolerated, failure to use a filter when making outdoor photographs is definitely an error except in those cases where the film used is sufficiently color-corrected and where correct exposure has recorded clouds if present.

13. Many smaller cameras have the lens mounted in a metal tube, the tube being collapsed when the camera is carried and extended when the exposure is to be made. When the lens is not extended, no definite image is produced. Instead there is a circular, blurred spot in the center of an otherwise unexposed film. A similar result is obtained by accidentally snapping the shutter of a conventional folding camera while the bellows is collapsed. At times grit will get into the lens mount and prevent its withdrawal to the full extent. At other times carelessness results in the same condition. The result is more or less focal diffusion, for which the rangefinder is unjustly blamed.

14. It sometimes happens that the film shows no image whatsoever after development. This occurs so often that we shall give it full attention. Usually the fault can be traced back to its cause, but sometimes it is impossible to recall any error of manipulation. We shall start with anecdotes of two actual occurrences. A woman bought a rollfilm folding camera immediately before starting a trip around the world. The salesman demonstrated the camera, although the customer inferred that any dumbbell should be able to snap a camera. The salesman also insisted that she learn to load the camera herself as she might often find herself in a situation with no assistance. The deal was closed and the camera paid for.

She returned the exposed film by mail, and the first batch showed merely some round holes with portions of an image in each. The dealer cabled her, and thereafter vainly tried to locate her, but to no avail. The trip was completed; every film was the same. She called for her pictures, and the dealer asked her to discuss the matter. Did she read the instruction book? No, she couldn't be bothered; the salesman had demonstrated the camera to her. Had she loaded her own camera? Yes, always. Then she was told that she had lost every exposure, and at once started talking about a suit for damages. Asked if she had the camera with her, she said she had, and produced it. The salesman opened the back, pointed to a board inserted to support the bellows, and indicated in big, red letters this notice: WARNING! REMOVE THIS BOARD BEFORE LOADING CAMERA! Had she read this? No, she couldn't be bothered, she wanted to take photographs! And that is the tyro in photography—but fortunately not the amateur!

A similar incident occurred with a man going into tropical Africa. He was more or less experienced, as he added considerably to his income by selling pictures. He had a new lens put on his camera, a lens fitted with a cap on each end. He put the lens in place, left the front cap on except when using the camera and forgot to remove the rear cap, an oversight not remedied until his journey was half completed!

Yes, there are many things which will prevent the image from being recorded upon the film. Exposures on sheet film in holders and packs in adapters are frequently lost by failure to draw the slide before exposure. This often happens to amateurs accustomed to the use of rollfilm cameras. When double shutter cameras such as a Speed Graphic are used, the unused shutter may be closed. If your camera has been left

where others have access to it, check the unused shutter before making an exposure. Shutters have been known to miss fire, thus preventing exposure. Often the diaphragm is closed to its smallest stop, resulting in severe underexposure. Again the use of a red filter

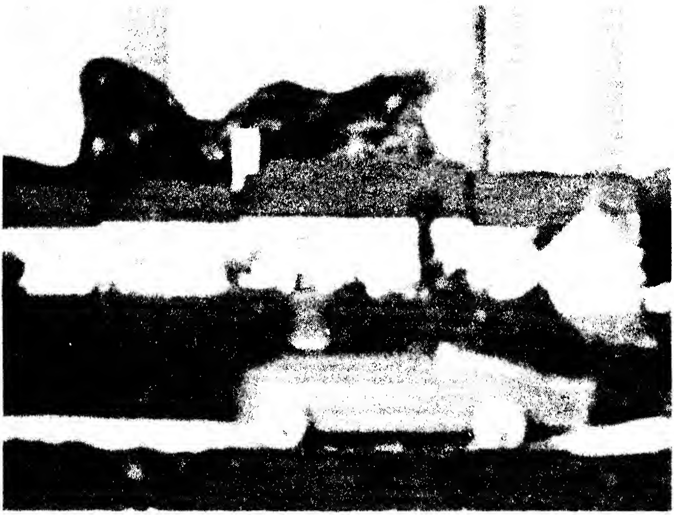


Fig. 165. Lack of sharpness throughout picture indicates that the camera was not focused properly; the negative is useless.

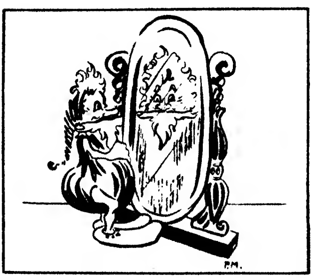
with orthochromatic film has been known to occur.

Finally there is that accident which has happened at least once to most of us, a mistake in filling the stock bottle which results in the film's being placed first in hypo instead of developer, and being completely fixed out. Among the rarest causes of exposure failure is obstruction by something inside the camera, such as a piece of paper, a loosened bellows lining, and so forth. Always examine the film carefully for the barest trace

of image to see if it is a case of no exposure or of gross underexposure, then try to recall what may have been the cause.

There are accidents which are often hard to trace back to their origins. This is the fault of having the lens partially obstructed at the time of exposure. The most frequent obstruction is that of a finger over the lens, but a portion of the carrying case, a strap loop, a neighbor's hat brim, or other object may get in the way. When the object is very close to the lens it may become unrecognizable because of its relatively huge size and blurred outline. Objects a little farther away become somewhat more sharply defined and are more easily recognized. The usual cause for such accidents is the fact that finders are set at one side of and above the lens. Finders centered above the lens are preferable, but in any case make sure there is no obstruction when you are shooting from close quarters. Obviously, single-lens reflex cameras are not subject to this type of error, as the eye sees the actual lens image.

15. When there are two or more exposures on the same film, the cause is obvious—failure to change or advance the film. In cameras which make use of the exposure counter instead of a film window, failure of the key to turn the film will result in double or multiple exposures. More often the film will move somewhat so that successive exposures are superimposed only for a part of their extent. In the case of sheet film the cause is usually failure to turn the slide around to indicate an exposed film.



Double exposure means a loss both of the film and picture.

A somewhat similar defect is found when a pack film is not fully removed; usually a result of tearing the tab too soon. The portion remaining in the aperture receives all subsequent exposures and becomes blackened. Each succeeding film is blank in a corresponding area where the projecting film protected it from exposure.

16. In this connection we may mention two faults which are, in a way, double exposure and partial exposure respectively. In some cameras using a focal plane shutter, the shutter may fail to close completely, thereby fogging a narrow band of film. When the film is advanced this band along the film, suggestive of a partial double exposure, is extended. When this dark band appears at one side of the picture and is carried across the dividing line between frames, however, the shutter is in need of repair.

The other fault is a transparent area in an otherwise good negative. This area is usually irregular in shape, with sharp edges. Torn pieces of film sticking in the aperture of 35 mm cameras will cause this, as will bits of torn paper in rollfilm cameras and either torn film or paper in pack cameras. Any foreign body inside the camera will give this effect. Blurred, blended edges suggest an obstacle inside the bellows but not close to the film.

17. Then there is that matter of focus. If a camera with coupled rangefinder consistently gives out-of-focus negatives, have the rangefinder reset. A general diffusion of the image indicates that the lens was not focused (see Fig. 165).

If the background is sharp and the subject is blurred, with the blur more evident in the direction from which the subject is moving, the shutter speed was not great enough to stop the motion (Fig. 166). If the background is sharp and the subject is uniformly diffused, the lens was focused upon the background

instead of upon the subject. This is usually seen when a lens of large aperture was used. In reverse—that is, sharp subject and blurred background—the effect is often deliberately used to gain a separation of planes and to emphasize the subject (see Figs. 167, 168).

18. If the entire image shows blur with a more or

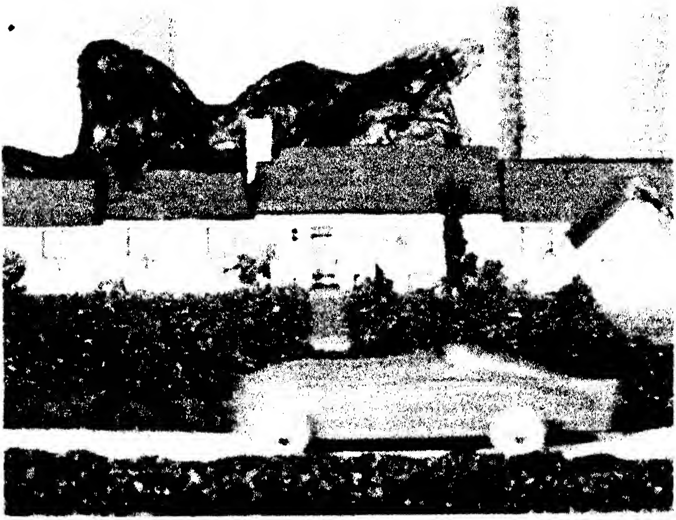


Fig. 166. Shutter speed was too slow to stop movement of the car, as is indicated by its blurred image. Note the double outline.

less distinct double line around all objects, the camera was moved during the exposure. This is usually the result of attempting too long an exposure with the camera held in the hands. Often the effect is not noticed until the negative is projected for enlargement (see Figs. 169, 170). As a rule, hand-held exposures with miniature cameras should be limited to a maximum of 1/50 second. For longer exposures one should

always use a tripod. Remember that any miniature negative should be able to stand enlargement to 11x14 or even to 14x17.

At times the center of the image will be blurred while the edges remain sharp. This usually happens (**a**) in damp weather or (**b**) when a bellows camera has the bellows opened suddenly. It is caused by the film's being bulged out into the camera aperture with the center of the film nearer the lens than the edges. To prevent this it is suggested that you make a habit of advancing the film immediately before exposure rather than immediately after. With bellows type cameras, open the bellows gently; do not open them with a sharp pull and risk bulging the film or sucking dust into the camera.

19. Long exposures are usually required when using a small lens aperture. We have already discussed the large aperture (see ¶ 17). The small aperture is used only when it is necessary to have the immediate foreground and distant background equally sharp. This usually results in the loss of all suggestion of depth and plasticity, so the small aperture is to be avoided except for some architectural and special landscape subjects. (If you belong to the "f 64 club" you're excused from following the general statement, and without argument!)

20. We have already devoted considerable space to the subject of under- and overexposure in previous chapters, so we shall not repeat the discussion here. It is enough to say that these are among the most common of all errors simply because many amateurs will not recognize the vital importance of correct exposure. Just remember that abnormal paper grades as well as intensification and reduction are simply remedies for emergency use, and should not be relied upon for routine procedure. As darkroom technique improves you will find less need for corrective measures.

21. The bad effect of a dirty lens is not realized by most amateurs. For a long time I was bombarded with inquiries as to methods for increasing negative contrast, and at a time when I was having trouble keeping my negatives sufficiently soft! In almost every case the amateur who was getting flat, gray negatives had for some reason failed to keep his lens clean, other than to blow off visible dust! A lens may appear comparatively clean yet be completely filmed with grease and fine dust. The lens must be kept clean—and a clean lens has an invisible surface! If you can see the surface it is not clean. The lens should be cleaned properly with plenty of good lens paper; use no substitute! But if it is allowed to become dirty, the resulting negatives will be too flat and gray to give a satisfactory print.

Keep the lens clean, but don't use abrasives on it.

22. And now for those vexing accidents which will happen in spite of all we can do. Among the first is the film roll coming loose in full light. We have already discussed this, so we shall pass on to the next. This is the fine scratch which appears mysteriously along the length of the film (see Fig. 58, Ch. V). It may run the entire length or a shorter distance. It is not confined to a single negative (unless in the case of a pack).

These scratches originate in the camera. First examine the small rollers over which the film face passes in most cameras. One of them may have developed a rusted bearing which keeps it from revolving freely, thus causing it to drag over the advancing film. A flake of enamel may have raised on the aperture

plate, making a tiny sharp blade to scratch the film. Maybe a bit of grit caught on the aperture and was later rubbed off; this is indicated by a scratch not running to the end of the film. Most films are scratched to some extent, but fortunately these marks are usually not deep enough to affect the printing quality of the negative. If a scratch persists in more than one film and in the same relative position, examine the camera (or film magazine) carefully to determine the cause.

23. Often a negative will be excellent except for a round black spot near one edge or in the center. Careful examination will show that this spot may have the suggestion of a numeral in it. These spots are caused when supersensitive film is used in an old camera which was made for use with "ordinary" film. The "film window" in which the guide numerals appear is not "safe." Light passes through this window, then through the safety backing paper, and fogs the film. Any film whose sensitivity runs down to or into the infrared is susceptible, because both window and paper are transparent to this radiation. When using any high-speed film keep the film window covered with black adhesive tape at all times when not actually advancing the film. All cameras should have a metal shield to cover this window. Some film windows are so unsafe that the exposure is great enough to produce a long smudge as the film is advanced.

At times, when the film has been stored in the damp, the printed guide numbers will offset to the facing film. This is seen as very faint, dark images of the numbers but with no surrounding dark circle.

24. Another troublesome fault is local fog, and its cause is hard to locate. This usually shows as a non-uniform patch of dark tone on the negative. Very often it has a definite fan shape and sometimes it is wedge-shaped. These marks are caused by minute

holes in some part of the camera—bellows, lensboard, etc. The location of the hole is aided by a study of the negative. The narrow end of the mark is closest to the hole, the light spreading into a fan or wedge as it gets farther away from the hole. Holes in the rear part of the bellows or in the camera body produce long, narrow wedges. Holes farther toward the lens produce fans, and holes in the lensboard produce general fog, but one in which there is usually a distinct core of greater density surrounded by decreasing zones of density which blend into one another.

If a very small aperture has been used, and there is a pinhole in the lens board, a faint duplicate image may be formed, offset from the true image. This is more rare than the fog effect, but also more puzzling.

Open the camera and place the negative in its camera position. Remember to have the emulsion facing the lens and the image upside down. The fog shape will then point to the general location of the hole. A small flashlight held inside the camera in a darkened room is a great aid to locating the hole. A hole in the camera body or lensboard may be stopped with a peg whittled from a toothpick and well coated with glue. A small disk of black adhesive tape covered with a larger disk of Scotch tape (or rubberized cloth cemented on) will effectually repair bellows holes. Again we have a series of faults for which there is little hope of remedy except in print retouching—and in a determination not to repeat the error. However, scratches are amenable to correction to some extent.

Some scratches are just that—gouges in the surface of the emulsion. Often, and especially when made during or after development, they are not accompanied by a blackened line. They appear black simply because of refraction at their edges. Light scratches sometimes can be removed by giving the negative a coat of good negative varnish. Deeper scratches may

be eliminated by the messy but efficient glycerin sandwich. Two glasses of size and thickness to fit the enlarger negative carrier are thoroughly cleaned. A pool of glycerin is poured on the middle of one plate, the film placed upon this and pressed down to eliminate air bubbles. Then glycerin is poured on top of the film and the other plate lowered into contact. Thus the film is sandwiched between the glass plates in a glycerin bath. The glycerin fills the scratches and thus prevents the refraction line. Obviously when the scratch is accompanied by the blackening of the abrasion mark, glycerin will not eliminate it. Take care to avoid bubbles in the glycerin, which would print as circles.

Faults Originating During Development.

The darkroom is the chosen playground for the "little people" who love to make mischief with negatives; surely no human being could be responsible for all the varied and vexing troubles which crop up there. It is somewhat difficult even to classify the possibilities in a form which will make for semi-intelligent discussion. However, let's just take them as we find them.

25. First there is the safelight. All negative work with panchromatic or any kind of supersensitive films should be carried out in total darkness. The changing bag is the ideal place for tank loading, and daylight tanks should always be used. In our laboratory a dozen tanks often are in use at one time, yet we have not used open tanks for almost ten years. The closed tank is more convenient, but it is even more valuable in being an almost certain preventive of light fog.

No light is safe for an indefinite time! Safelights should never be used with bulbs larger than specified (usually 7 or 10 watts). They should never be used nearer the film than specified, usually a minimum of 3

feet. Safelights should never be used for a longer period of time than is specified for the particular emulsion used. To be on the safe side, safelights should never (or at best rarely) be used for manipulation of negative material.

One phenomenon which so often puzzles beginners is the negative made up of a more or less positive rather than a negative image. This usually results from exposure to unsafe light before the conclusion of development. Films developed in a tray and exposed to a very feeble, unsafe light throughout the time will almost invariably show this peculiar reversal. This is the basis of the so-called "solarization" processes, although it is not a reversal on the downcurve of the H&D curve at all, but a "printing" process similar to that used in deliberate reversal.

26. The developer should be mixed from fresh, full-strength chemicals. Using a chemical which has lost 50 per cent of its active power is equivalent to using half the specified amount! And even dry chemicals do lose their strength. Specifically, old chemicals will tend toward fogged or stained negatives, non-uniform development, and underdevelopment. The same thing applies to errors in mixing where insufficient amounts are used. Too little sulfite, for example, tends to give yellow stains, a result which follows the use of too much carbonate, and so on. Follow a reputable formula.

Hypo and developer are both essential—but don't mix 'em.

27. In preceding chapters we have discussed the effect of temperature upon development, so that we

need not go into this subject here. Remember to keep the developer as near as possible to the optimum temperature, and do not resort to such devices as the use of sulfate when it is physically possible to reduce the temperature.

28. The effects of over- and underdevelopment also have been fully discussed in preceding chapters, so that subject may be dismissed without further repetition here.

29. Darkroom fingerprints are often troublesome, especially when tray development is used. The foremost remedy for darkroom fingerprints is to use a tank for all negative development. Fingers damp with developer tend to produce fingerprints darker than the rest of the negative, often fringed with a yellow or brown stain. This happens when the dry film is touched under such conditions.

When the fingers are damp with hypo, the prints may be transparent if the hypo is present in quantity to fix clear through the film. More often they are merely lighter than the surrounding area, and in this respect may be confused with oily fingerprints made at the time of loading. The hypo print, when not completely fixed out, usually is surrounded with a suggestion of fog.

30. Fingerprints are akin to other chemical contamination. If chemicals are mixed in the darkroom, very often developer dust will float in the air and settle on the dry film. When it is put into the developer solution, the grain of dry developer begins to act very energetically and overdevelops that spot. Often there are "rays" of tiny black threads shooting off from the speck, and on the absence of agitation there will be a "tail" descending toward the bottom of the tank.

Sometimes these spots are a clear, bright blue; this indicates the presence of iron in one of the solutions. This color is an unmistakable blue, and should

not be confused with the purplish blue of some developer spots. The cause usually lies in water which has some iron content or which flows through iron pipes; but sometimes it comes from the use of enamel tanks or trays in which the enamel coating has cracked, thus permitting access of the solution to the underbody of iron or steel.

31. If too much developer is carried over into the hypo through failure to use a rinse or stop bath between development and fixing, the acidity of the hypo will be neutralized by the alkalinity of the developer and trouble will arise (see ¶ 47).

32. When the cause is reversed and hypo gets into the developer, the most common result is the surface deposit of silver, which appears as a purplish to brown stain whose surface reflects light with a silver sheen. This also happens at times in old developers (or warm ones) which contain an excess of any bromide solvent such as sulfite. The stain can usually be removed by carefully scrubbing the film with wet cotton before it has dried.

33. No one can be condemned for exercising the strictest economy; but in photography attempted economy often turns out to be the rankest extravagance. This is particularly true in the case of working developers beyond their exhaustion limit. The trouble is that an exhausted developer will continue to develop, but it also produces a variety of stains, spots, and marks, so that the beginner is confused. If developers would only stop working when exhausted these problems would be simplified, but such is not the case. The most common effect produced by old developer is uneven development. This may show up as a general mottling of the image, which shows most plainly in the larger even areas. The mottled pattern may enlarge until there are cloud-shaped areas of different density, much as though the film had been immersed

in the developer a portion at a time. This will occur even when the tank is agitated.

Another effect of old developer is the yellow to brown stain of oxidation. As this stain can result from so many causes we will discuss the remedy here, and

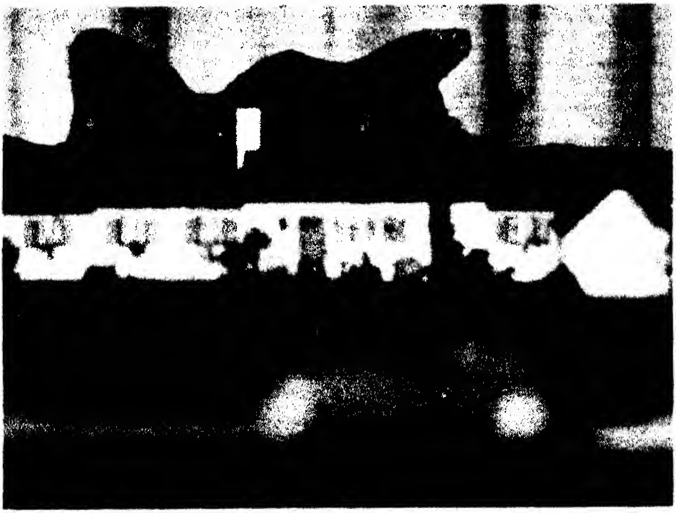


Fig. 167. Depth of field is shallow at large apertures. Here the lens, at f 4.5, was focused on background; foreground is blurred.

subsequently refer to this section. Yellow to brown oxidation stains may be light or heavy; they may be limited to the edge of the film, extend over a large portion, or even over the entire surface. In some cases, such as a film's not being fully immersed in the hypo but left to float, the stain may be centrally located.

A remedy is to harden the negative in a ½ to 1% formalin solution to which has been added sodium carbonate to about ⅓% or ½%. Bleach the negative

in the familiar permanganate bleach ordinarily used in the reversal process (see Chapter V, page 321). This stains the negative brown. Remove this brown stain with a sodium bisulfite bath (same formula as for reversal). Rinse the negative and develop it in a non-stain

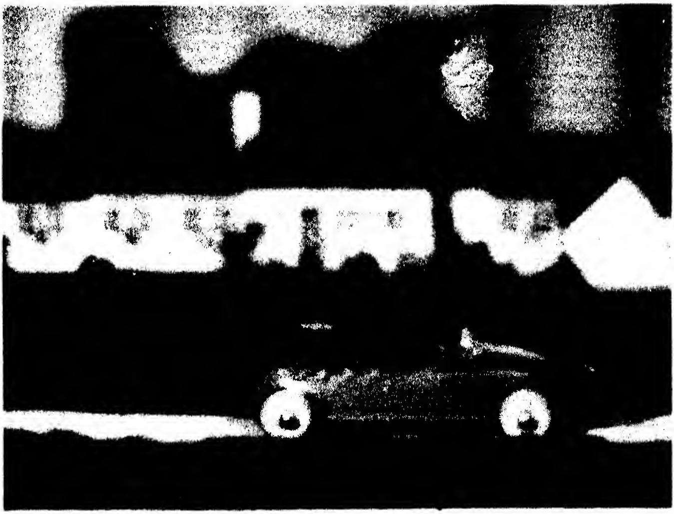


Fig. 168. In this instance the lens, still at f4.5, was focused on the foreground object. Compare the illustration with Fig. 167.

developer. This development is carried out where there is plenty of actinic light, such as diffuse daylight or a 100-watt incandescent work light.

34. Another false economy is the use of too little solution, but as this applies only to tray development it is not so common. Tray development with a minimum of solution is prone to result in oxidation stains as described above.

35. Much has been written and said about the

evils of stagnant development, and most amateurs acknowledge the truth of much that is said by shaking the tank two or three times during development. The practice of constant agitation cannot be too strongly recommended! No matter how carefully you work, constant agitation will produce better results than will stagnant or semi-agitated development.

The most obvious results of no agitation are the highlight streaks or lighter areas that will be seen running from dense highlight areas and film perforations in a direction that was downward when the film was in the tank (see Fig. 171). The exhausted developer released from a dense area may, on diffusing downward, restrain development in the portion below, as shown. These same streaks are present in semi-agitated films, but there is a point beyond which the streaks are not visible. Under certain conditions lack of agitation will produce a negative in which the streaks are not visible as defects in the negative; they will, however, cause the characteristic light streaks in the projected print. The negative streaks are apparent only upon closest examination. By all means, agitate every tank of films you develop.

36. Streaks similar to those described above are also produced by the use of racks, reels, and tanks which have been used for fixing and from which the hypo has not been thoroughly removed. They also occur on films developed in racks, reels, and tanks which are used for developing only, and upon which developer is permitted to dry. For the best results it is advisable to use the same tank for developing, fixing, **and washing,** as the washing serves to clean the tank as well as to clear the film.

37. When more than one film is developed in a tray there is great danger of scratching the soft emulsion, for sooner or later you will miss your grasp and your fingertips will slip across the face of the film. As

tray development is becoming rare, this danger is not great. However, there are other scratches which occur in tank development. In sheet film tanks a tear may be started in one of the holding grooves or by the retaining band. In loading any tank be sure that the film is not under tension, although it must always be held firmly in position to prevent slippage.

Obviously scratches are beyond repair when they are so large that even minute particles of the emulsion have been loosened from the base. Here again, total loss may be avoided by skilful positive retouching.

38. There is one result of uncleanliness and false economy which we have seen often but have not always recognized. This is a silver stain, but the silvery sheen is not always present. The stain is definitely pink when the negative is held before the light, but by reflected light the color is greenish. This is **dichroic fog,** and consists of a deposit of colloidal silver upon the negative. The causes are many, and it may occur in either developer or hypo. Any bromide solvent, hypo, an excess of carbonate or of sulfite, or ammonia mav produce it. If the hypo bath is exhausted, not sufficiently alkaline, or loaded with dissolved silver (as is the case with an old bath) it may occur here.

To remove this fog dissolve 10 grains of potassium permanganate in a pint of water and immerse the film until the stain is gone. Remove the brown permanganate stain with 10% solution of sodium bisulfite, and wash the negative thoroughly.

39. Did you ever work in the darkroom with the type of amateur who goes swimming every time he develops a film? Solutions are dripped on the sink, on the floor, on clothing, and for good measure flicked all over the room when he shakes his wet hands instead of using a towel. This is not only careless; it is dangerous! There is no reason why developing cannot be done upon a library table protected with a single

folded newspaper. The entire spillage may be limited to a tablespoonful of liquid without using any undue care.

Negatives will occasionally show strange black or transparent spots. Usually there is a string of two or more spots of diminishing size, and often there is a suggestion of pear shape. If developer is splashed upon a dry film it starts to develop. Then when the film is placed into the developer, these spots are still further developed and come out as black or very dark spots. On the contrary, if hypo is splashed on the negative, the emulsion is fixed out, and the result is a similar series of transparent spots.

Water is not harmless, for if water is splashed on the film the gelatin is softened and develops more rapidly, producing spots which are definitely darker than the rest of the image. So when you go into the darkroom remember you are going to develop films; you are not going to take a bath!

Obviously there is no direct remedy for these spots. Some remedial work may be done by positive retouching, so we shall not discuss it further here.

40. There is a definite relationship between density and the time during which the developer acts, as we have seen in the case of the developer splashes. This reminds one of an accident which happens too often for comfort. In many amateur laboratories developer is poured from the bottle into a graduate and then into the tank. Also in many such laboratories there is no graduate with a capacity as great as that of the tank. When this is the case, a graduate full of developer is poured into the tank, and then the graduate is refilled and the tank filled from this second portion. The developed film exhibits one side of the negative slightly darker than the other with usually a fairly sharp line between.

Some amateurs shake the tank while filling the

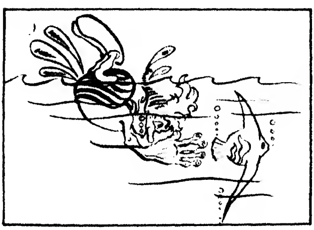
graduate a second time, then hold it still for filling, with the result that the dividing line takes on strange undulating outlines near one edge of the film. Always pour developer from some container with a capacity greater than that of the tank being filled.

41. Closely akin to the accident described in ¶ 40 is that encountered in some types of tank. There are tanks which are practically airtight and filled with a spout which runs down near the bottom. If filled rapidly, the air has no chance to seep out, and the filler spout overflows just as it should with a full tank. This air trap means that the film is only half covered. If there is no agitation there will be a sharp dividing line between the fully developed image and no image at all. Agitation will provide a blended edge through which the density decreases from full strength to zero.

So much for errors caused during development. There are others; in fact, the variety is infinite, but they are more rare. Our discussion has covered all those which are commonly encountered.

Faults Originating During Fixing.

42. Before going into the problems of fixing, we must give some attention to that important intermediate step, the rinse or stop bath. Ordinarily a thorough rinse in water is sufficient, particularly if a fresh hardening hypo bath is used. However, it is undeniably preferable to make use of the usual acid—chrome alum stop bath between developing and fixing. Not only does this harden the emulsion, but it also



Air bubbles will stick to film unless it is agitated.

is a powerful agent in preventing a multitude of stains, spots, and marks. It is inviting disaster to remove the film from the developer and place it directly into the hypo bath. A fresh, acid hypo bath will stand this for a few times, but too soon it loses its resistance, and then a whole legion of defects marches in and takes possession of the field.

Some tanks have closely adjacent plates, ridges, or other parts which hold developing solution between them by capillarity. This developer does not leave freely when the film is rinsed. When the hypo is added the developer will seep out and persist longer than in the free areas. The result is an irregular, wavy cloud extending inwards from the edges of the film, as areas of greater density. Sometimes the increased density is barely perceptible, at others it is quite heavy. The use of the chrome stop bath will eliminate this as well as many other mysterious spots and abnormal density differences.

In this connection it may be added that removing a film from a strongly alkaline developer and plunging it directly into strong acid hypo sometimes causes the production of gas bubbles between the emulsion and the film base. These bubbles, often (although not invariably) of minute size, burst through the emulsion with the result that small pinholes are formed, and when these are present in any quantity the rough edges of the emulsion around the burst bubbles feel not unlike sandpaper.

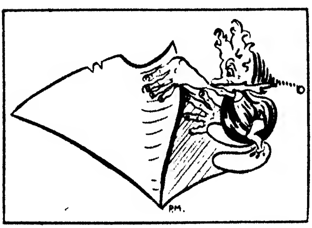
43. There is one common defect which is encountered in both developing and in fixing, and which has not been mentioned. Because of its duplex character it is included here to save repetition. This is the spot, circular or almost so, which has a soft blended edge, although at times it may be so abruptly shaded as to resemble a sharp edge. It may be quite transparent, or more commonly the image appears in it but much.

lighter than in the surrounding film area. In other cases it may appear as a clear yellow spot which rapidly turns black under white light.

These are air-bubble spots. If an air bubble sticks to the film when developer is first applied, it prevents the solution from reaching the emulsion. Afterward, this undeveloped spot is fixed out in the hypo, leaving the transparent spot. As the developer tends to fill in the spot against the air pressure, the edge is more or less blended and rarely sharply defined.

If the tank is shaken at about the midpoint of development and the air bubble dislodged, the spot will begin to develop, but as it lags the rest of the film will be much lighter in density. If, however, the film is fully developed and catches an air bubble in the hypo, the spot will show the image against a background of yellow, unfixed bromide. If not removed by the application of hypo, this bromide turns black, obscuring the image in the spot area. Thus we see that air bubbles have a definite action, but that the results of this action vary with the solution in which the bubbles occur.

44. Another fault common to both developing and fixing, but fortunately more common in the latter, is the sticking together of two films, or two adjacent turns of film in a spiral tank. In the case of development, either the touching surface of the back film does not develop at all and fixes out as a clear central portion, or the solution gradually seeps in and produces a gradually decreasing density to a very light center. There is nothing to be done about this. However, when films develop all right but stick together in fixing, the rear-



Don't let wet film surfaces touch when in the solution.

most film simply shows an unfixed center, and if promptly returned to the fixing bath, the error may be remedied, usually without any trace of the accident remaining.

There is one result of films sticking together in the hypo bath which is bad. If the films stick together at the time of removing the developer, and remain stuck during rinsing (rarely will this persist throughout a 5-minute stop-bath treatment) the touching edges carry developer into the hypo by capillary attraction. This developer produces the usual purple stain, but under these conditions the result is usually a purplish stain which may blend outward into the more familiar yellowish brown one. If the image is fully developed, the clearing remedy already described for developer stain (¶ 38) may be successful in removing it.

45. And now let us consider those faults which are strictly related to the step of fixing, itself. A frequent cause of trouble lies in making the bath, because too many amateurs think the fixing bath can be mixed carelessly by guessing at weights and quantities. This is a mistake; an out-of-balance bath can easily have its acid content exhausted, have an excess of alum, precipitate sulfur, or be too weak or too strong. Most of these troubles have been discussed in the chapter devoted to fixing, but it will do no harm to repeat the less obvious difficulties which may be encountered.

An excess of alum in the hypo at times causes pit marks. These are tiny conical depressions in the emulsion, similar to defective coating spots but with more abrupt edges. This does not occur too often, and when it does the holes are often confused with the pinholes of burst acid bubbles. These marks sometimes follow too rapid drying.

46. Films may inadvertently be hung up to dry without being washed, or after only a brief rinse. In such cases the hypo will crystallize out upon the sur-

face of the film, giving it an appearance strongly resembling a frosted window pane. If this is seen before the reducing action of the hypo is evident and before any yellowish deposit of silver sulfide appears, the film should be thoroughly rewashed and dried.

47. If the acid in a hardening hypo bath has become exhausted, a white scum may be seen on the surface of the negative. This is a precipitation of aluminum sulfite. It can be removed **before the film has been dried,** in a strong carbonate solution. Harden the negative in 1% formalin, bathe it in 5% to 7% carbonate until the scum is gone, and then wash it thoroughly.

Oxidation stains sometimes arise in fixing, especially when the bath is exhausted. It can easily be seen that these occur under conditions which will also produce other faults, and the appearance of two or three faults may serve to mask one another producing the appearance of something entirely different. However, the most prevalent cause of oxidation stains is permitting the negative to protrude from the hypo bath. The protruding portion, not having the developer neutralized, will acquire the specific developer oxidation stain, even though the negative is in the hypo.

It must be remembered that the hypo does not stop developing action immediately, but that development proceeds to some extent within the body of the emulsion for from 20 seconds to one minute after immersing it in the hypo. Obviously the use of a stop bath will effectually prevent oxidation stains from originating in this manner.

Obviously, if the negative remains partly out of the hypo throughout fixing, the image will be only partly fixed. This can be remedied at once by immersing the film in hypo until this spot is cleared up. This may leave a slight difference of density, but usually

not a serious one. However, if the unfixed portion is exposed to strong light, there will be a spontaneous breakdown of the bromide. This leaves a dark deposit which is really one form of chemical fog as it is composed of reduced silver, just as is the image.

48. If the hypo is old or warm, or both, there may

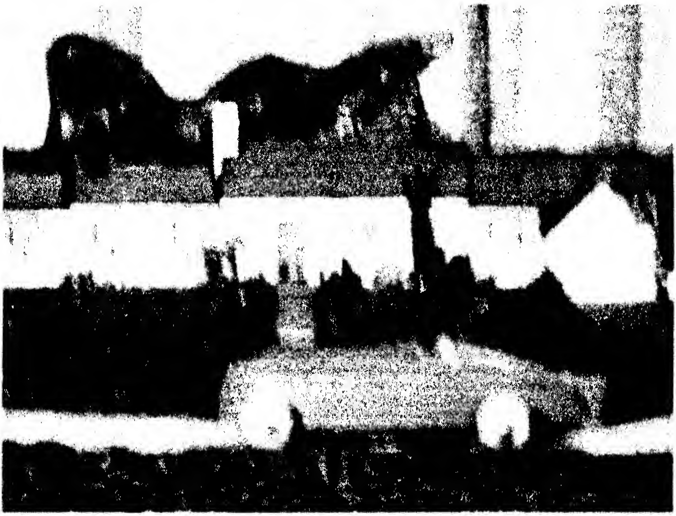


Fig. 169. A blurred picture with a more or less distinct double line around objects indicates camera movement during exposure.

be a precipitate of sulfur. This, too, is white, a rather soiled white with a suggestion of yellow, and the texture of the deposit is more definite than the amorphous texture of the aluminum sulfite. Precipitated sulfur is obstinate, and there is no remedy which is really satisfactory. The best preventive is to avoid using fixing baths to the point of exhaustion.

49. When chrome alum is used either for harden-

ing in a separate bath or in the hypo, the bath must be kept acid. As soon as the bath becomes neutral or alkaline there is grave danger of an alum deposit on the film, which appears as a greenish white scum. Fortunately this scum is not very tenacious and can be removed by carefully rubbing the surface of the film

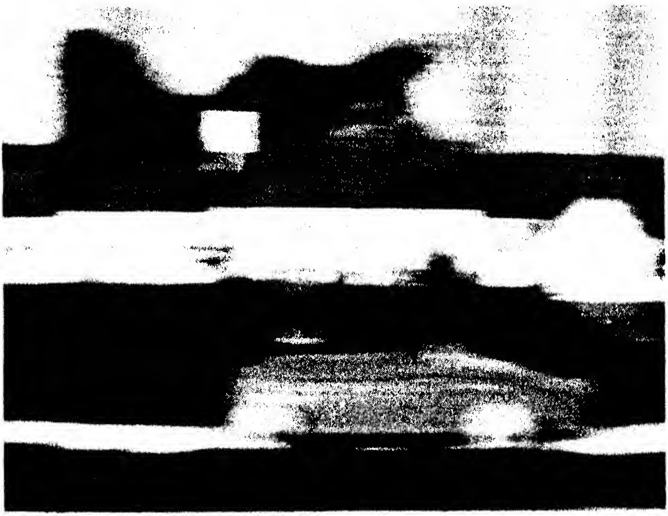


Fig. 170. Effect here is similar to that above. This one shows horizontal movement, while Fig. 169 shows vertical movement.

with a pad of absorbent cotton kept saturated with water. Do not use a moist or squeezed out pad, but use plenty of water. A good procedure is to fill a tray (8 x 10 or larger) with water, immerse the film, and rub it as it lies on the bottom of the tray.

50. Fortunately hypo does not deteriorate badly in solid form, and acetic acid keeps very well. There may be some loss in alum, but the sulfite is the worst

of all. Make a practice of using only fresh sulfite in all photographic work. Perhaps the granulated form is more stable than the powder. The sulfite is prone to change spontaneously to sulfate, and to the extent of this change it loses its power as a preservative.

When the solution is made up it should be water clear, any turbidity or milkiness indicating the probable presence of free sulfur, always a factor of danger in a fixing bath. As soon as the bath becomes even slightly turbid it should be discarded.

This brings up a negative fault which I have encountered time after time. The negative is inclined to be flat, the tone not quite uniform. Its general appearance is quite similar to that of an old film, except that the density is lightest around the edges, whereas in old films the edges usually present the deepest density. This type of negative error puzzles many beginners. Examine the negative carefully in moderate or subdued light, holding the film so that the surface is seen by reflected light just as you would hold a book for comfortable reading. The negative will display a **barely perceptible** tinge of dirty light gray. That is about the only way to describe it. This tone is almost that which would be seen by holding a sheet of gray-white rough paper some distance beneath the film.

This trouble is simply insufficient fixing. Beginners who rely wholly upon time for processing will leave films in the hypo for 15 minutes, then wash them. It should be remembered that the fixing bath works more and more slowly as it is used. A time comes when all the visible bromide will not be removed in 15 minutes, but as the greater part is removed the remainder shows this faint, gray veil which is not at all like the completely unfixed film. When this happens, make up a fresh hypo bath, replace the films in it, and fix for at least 10 minutes; then wash and dry.

This fault rarely results from false economy.

Rather, the hypo is made up and used from time to time, and before it begins to weaken the amateur has forgotten the extent to which it has been used. Keep track of the use which the hypo receives, and regardless of this record discard the hypo when any of the following are seen:

a. Solution starts to become turbid or milky.
b. Has an offensive odor like that of decomposition.
c. Produces heavy froth when violently agitated.
d. Fails to clear the film in twice the original time.

This last point needs some explanation. The time for clearing in a fresh bath depends upon the type of emulsion. Positive film, for example, will clear in 25 to 30 seconds, while a fast pan emulsion may require 3 or 4 minutes. However, regardless of the film you are using, it is safe to open the tank under the ordinary darkroom work light after the film has been immersed 3 minutes. Make up a fresh bath, put the film in it, and in 3 minutes examine it. If it is not quite clear—that is, if there are still traces of gray deposit—return it to the hypo and examine at 15-second intervals. When the film is fully cleared note the time. For the sake of example, suppose it is clear in 3¼ minutes. Now as soon as the hypo reaches the stage where it requires 6½ minutes to clear that same type of film, it should be discarded. Incidentally, the fixing times in these two cases would be 6½ and 13 minutes respectively—in any case twice the clearing time.

51. There persists a superstition that a plain fixing bath will produce a better negative than a hardening hypo. Many comparative tests (using different films and several types of fixing baths) made under test conditions in our laboratory have shown that there is no appreciable difference once the negative is safely dry. It is true that in print making there is some dif-

ference, although hardly as much as we are at times led to believe. But we are concerned with negative making, and it cannot be stated too emphatically that every negative should be treated with an alum hardening bath or a hardening hypo; better yet, use both. Yes, it is definitely advisable to harden the film in a chrome alum-bisulfite bath between developing and fixing and then to fix the film in a white alum-acid hypo bath.

Some researchers claim that the intense hardening of the film by the two baths results in a greater compacting of the granular strata in the film, and thus makes possible a greater degree of enlargement through the reduction of light scattering at the edges of definite tones; this action is similar to the irradiation which resembles halation in the exposure. This seems to be splitting hairs, but as the prescribed hardening process will certainly not injure the negative, there is no reason for not using them. There is no danger of having an exhausted hardening bath, because it does not keep and **must** be made up fresh for each batch of films developed. However, the use of this bath will insure hardening in those cases where you have become careless and have allowed the hypo bath to become overworked.

52. Just what are the ill effects of the non-hardening bath? Softening of the emulsion! This may reveal itself in many ways, the least harmful of which is an overswollen gelatin. The surface feels slippery and the film is hard to hold between the fingers. This is always a danger signal, for even a firm grip between the finger and thumb may crush the gelatin or even tear it. When the negative is in this condition it should be submitted to a hardening bath immediately. It is much better, however, to prevent this excessive swelling than to remedy it after it has occurred.

The next step is frilling. The gelatin leaves the

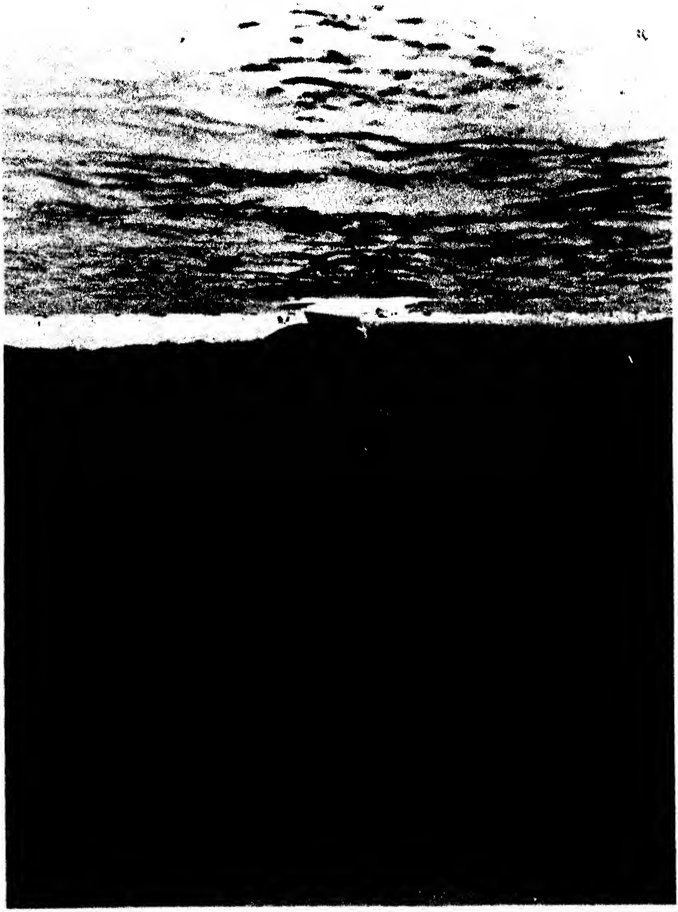


Fig. 171. Processed without agitation, this negative shows a lighter area running downward from dense highlight (see No. 35).

film base, and by even greater swelling the free gelatin becomes ruffled along the edge. Even now the negative can be saved if the image is limited to the center of the negative, but the ruffled edge cannot be restored to its original position. In the case of an extremely valuable negative which cannot be replaced, it is in some cases possible to complete the removal of the gelatin and allow it to dry upon a glass plate. This operation is so rarely successful that it should be regarded only as a vague possibility and not as a serious remedial measure.

At times the gelatin leaves the base in the inside area of the film instead of at the edges. These "blisters" become filled with solution and the gelatin is stretched so that the blister cannot be returned to its position even if the contents of the blister are removed. If the blister is small, not more than about one or two millimeters, it may be allowed to dry down and the defective spot remedied by print retouching, like any other spot defect. Under this condition of swelling, the emulsion will tear at the slightest touch of the fingernail, print paddle, or even the corner of another film. In fact the pressure of water against a frilled edge as the film is moved in the tray will often be enough to start a tear.

53. These are the most apparent difficulties, but there is another which causes more trouble than all other soft-gelatin faults put together. A negative is often removed from the wash water and the face, instead of remaining glossy and wet, loses its surface moisture very rapidly, quite similar to the drying action of damp groundglass. The surface looks matte instead of glossy. At other times it comes out of the water in normal condition, but when hung up to dry takes on this same matte appearance after a longer interval. This is **reticulation,** which has already been discussed (Chapter VI). There is no remedy, but

when the effect is barely perceptible in the wet film it may dry out all right. This, however, is only a bit of good luck and not to be expected. As a rule the reticulated film is lost.

One more exception is that in the rare case of a perfectly uniform reticulation throughout the film, a print may be made which bears a definite resemblance to one made with a texture screen. If you happen to like this effect you can make use of an occasional reticulated film, but otherwise such negatives are discarded.

The true remedy lies in using a good hardener, and as we have said the best way to insure this is to use the double bath. It is too obvious to repeat that a warm hypo bath not only tends to decompose but hastens any tendency to swelling and all the resultant faults.

54. Once the negative is safely fixed, the amateur usually considers his troubles are over, and this unwarranted confidence is the cause of too many lost negatives. Remember, the negative is never safe until the print has been made from it. As we shall see, the negative is not even safe in storage.

Faults Originating in Washing and Drying.

Negatives should be washed in running water with some kind of support which will insure thorough washing of both film surfaces. Washing in the original tank is perhaps the best amateur routine. This applies to sheet films as well as to roll film. It is always bad to wash sheet films and pack films in a tray. There is danger of scratches by the films sliding over each other, thus rubbing in any grit particles which are always found in tap water. Also, films are inclined to stick together, and thus complete washing is made impossible.

55. One evidence of incomplete washing or of incomplete fixing, or both, is the common **fading,** wherein the image gradually turns into silver sulfide. Amateurs often remark that it is strange that this might result from either poor fixing or poor washing—but is it curious? The fading results from the presence of the silver thiosulfates in the film. These are produced first in an insoluble form, and if fixing is not complete some of them remain insoluble and cannot be removed by washing. On the other hand, if they are all in soluble condition but washing is not continued long enough, they are not all removed from the film. So we see that the two technical errors result in the same chemical fault.

56. Washing must be continued until the hypo concentration is reduced to one part in ten thousand or less. This can be ascertained as already described in Chapter VI. Time can be made a basis for control, the wash water can be chemically tested for hypo, or the electric conductivity meter used for a determination of the hypo concentration. But whatever method is used, be **sure** the hypo is all out. A 10-minute wash may keep a negative for 5 years, but if an additional 5 minutes adds another 10 years to its life, why not take the extra time?

57. Tap water or water from wells is often "hard," and quite often the mineral content is sufficient to leave a scum on the film. This must not be confused with the oil-dust scum that negatives acquire from development in tanks which are kept open and filled with solution. This oil-dust scum usually responds to cleaning with carbon tetrachloride, but the water scum, once it is dry, is extremely obstinate. If this trouble occurs, wash the films as usual. Then rub them on both faces with a pad of wet cotton, rinse, and repeat the scrubbing. Rinse it again and dry with a sponge, squeezed cotton or, best of all, negative blotting paper.

Fig. 172. Pieces of grit in the sponge produced scratches in the soft film emulsion when it was wiped down after washing.

If the scum persists after this treatment, try more scrubbing, followed by rinsing in distilled water.

If water is allowed to stand in a tray or tank, a transparent slime will form. Unless the containers are washed out carefully, this slime will collect on the film and when dry show as a thin scum. It is advisable to keep all utensils empty and dry except when they are in actual use, and the amateur is particularly cautioned against keeping a permanent setup of tanks with the solutions standing from day to day or week to week. This practice is only practical when the solutions are used daily and changed at frequent intervals.

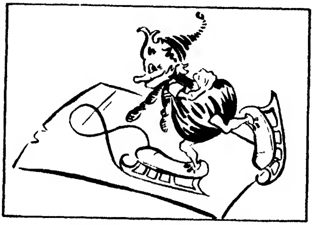
58. No film should be hung up to dry with water dripping from it. The surface will dry, but there will be drops of water standing on both front and back of the film when the rest of the surface is half or fully dry. These drops leave spots of abnormal density, often marked with a dark ring around a light center. It should be remembered that a water drop on the **back** of the film will leave such a mark, because the drop on the rear of the film prevents the emulsion from drying as rapidly in that spot as in surrounding areas. Because of their small size, such marks are almost beyond remedy. The films should first be surface-dried with a sponge or negative blotting paper such as Textilex, and then hung up to dry.

When using a sponge, chamois, or cotton for wiping down the film be sure it is perfectly clean. If even one grain of grit or iron rust from the pipes is picked up it will scratch the surface of the film. These scratches are easily identified as they are usually long, running substantially parallel with the edge of roll film, but usually slightly curved. The washing material must be flushed with water and squeezed dry after each stroke over the surface of the film (see Fig. 172).

59. Films should be dried in a place where there is a circulation of warm, dry air. The most important

factor is the circulation, the second is the dryness, and last of all in importance is the temperature.

For rapid drying films can be hung between two infrared lamps with a fan blowing across the film edgewise. If the fan is omitted or if only one lamp is used, the film is much more inclined to curl and buckle. If the lamp is too close this also happens, because the center of the film dries more rapidly than the edges. The lamp should be from 12 to 18 inches away. If rollfilm is used, it should be raised and lowered steadily between the lamps.



Scratches can be avoided if film is handled with care.

Ordinary heat should never be used for negative drying as it will often melt the gelatin. Mild cases merely show the image with wavy, distorted outlines. More serious cases result in the emulsion's sliding entirely off the film base. Indeed, this has also been known to happen in the hypo bath when plain hypo was used and allowed to get to too high a temperature.

60. A drying machine is advisable. Several are available on the market, and one can be made at home by those amateurs who take pleasure in home craftsmanship.

61. If the film dries unevenly, there will be a corresponding change in the density, which fault is almost identical to the dark ring observed in the water drop mark. Films which take long to dry are more susceptible to density changes than those which dry rapidly. Stagnant and moist air prevent normal drying.

62. The use of fans is advisable when drying, but care should be taken that they do not produce a dust

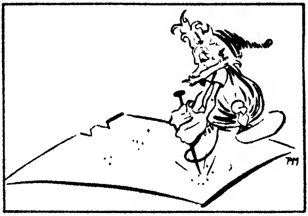
storm. Half-dry emulsion is almost as tacky as glue, and any dust which settles on the drying film almost invariably becomes a permanent part of the negative. A drying device that is easily arranged and which serves quite well is made of one of the inexpensive cardboard closets used to protect winter clothing from moths. The type with the roll door works out quite well. The closet is set up and carefully dusted. A darkroom ventilator fan is attached to the closet in front of an opening at one side near the bottom, and on the inside of the fan opening are placed two spun-glass diffuser disks to act as a dust filter. In damp or cold weather an electric heater coil may be placed immediately outside the fan intake. A cloth-covered air outlet should be made in the top of the closet. Thus at a total outlay of just a few dollars you have a complete forced-draft, dehumidified, dustfree film drying cabinet! It is well worthwhile because it will not only improve your negative quality but will free you from an astonishing quantity of dust problems.

At times the dry film shows a pearly opalescence instead of clear transparency. This is caused by several things all having to do with rapid drying. The use of strong alcohol will usually produce it, as will rapid drying in an air current that is too dry and warm. The effect sometimes passes spontaneously, but if it persists, the negative is soaked in water until thoroughly impregnated and then dried more slowly.

Faults Originating After the Negative Is Dry.

63. When the negative is dry it is usually polished. This may be done with film-cleaning solutions or carbon tetrachloride in which 5% of its bulk of paraffin has been dissolved. For the simplest cleaning, straight carbon tetrachloride will serve very well indeed. However, the cleaning must be done with a soft cloth.

Chamois is not advisable because it isn't kept clean. As soon as the cloth is discolored it must be changed for a fresh piece, because any particle of grit picked up will act as a chisel. Soon the cloth acts like emery paper instead of a polisher, filling the film with minute, almost invisible scratches which become painfully apparent upon enlargement.



Particles of grit produce holes and marks on the film.

Although careless polishing is dangerous, careful polishing is essential. Negatives, even those rinsed in distilled water, have a certain amount of surface scum. Quite often there are definite sludge spots on the film. These must be removed. It might be remarked that faint water marks on the back of 35 mm film are best removed by brisk scrubbing with a clean cloth wetted with denatured alcohol. Wood alcohol has too much of a solvent action to be advisable. This applies to **35 mm film only,** as other films have a gelatin coating on the back as well as on the front, and are best cleaned with carbon tetrachloride.

64. When the negative is polished it is ready for filing. This is far more important than most amateurs realize. How often have you heard friends remark that a certain negative has more scratches on it than it had when last used? This usually brings forth loud laughs, but it is quite true. Films which are kept in rolls, as are so many 35 mm films, will develop scratches in the storage box. Particles of dust and grit are held by the film surface, and when the film is rolled up these particles are held between the layers of the film. Almost always the film is rolled loosely and then "cinched" to make the roll small enough to fit the

storage box compartment. This invariably causes some scratches. Then in the box itself as the atmosphere gets colder and warmer, drier and more moist, the film expands and contracts, and the layers of film rub against one another. Each movement digs the dust into the emulsion and minute scratches are formed.

Just as soon as it is cleaned the negative should be placed in an individual protective envelope. This may be of any kind of paper, but cellophane or glassine is preferable. Waxed paper tends to offset wax on the negative and should not be used. For smaller films, single envelopes may take a series of frames, and in the 35 mm size some preservers are so made that one piece contains several such enclosures. Thus an entire roll of 35 mm film is held in pieces of four to eight frames, flat, and individually enclosed. The value of such protection cannot be overestimated.

I have in my possession 35 mm films made in 1922 which have been so preserved, and today seem to be quite as usable as when new. Certainly they do not show more scratches than many freshly dried negatives. No, the conventional 35 mm camera was not available in 1922, but single-exposure cameras using this film were available.

65. And finally we have those defects which arise while the negative is being used for printing or enlarging. There isn't so much danger involved in printing, but the enlarger is a constant source of danger.

Enlargers with glass pressure plates are worse than those using open plates, but even these will scratch the film. You cannot eliminate dust entirely, and if you position a negative by pulling it through the film holder while the holder is closed, you will surely scratch the film to some degree. In fact, even those enlargers which have means for releasing pressure are not free from danger, for even here the film is often forced down against the plate in one or more

spots. The only safe way to change films is to remove the negative holder from the enlarger, place the desired frame in the aperture, close the carrier, and insert it. Then adjust further positioning by moving the easel on the baseboard.

66. Another source of injury in enlarging is that of heat. If a very dense negative or small aperture necessitates a long exposure, the film may become so heated that it buckles. It will retain this wrinkled form thereafter, and unless the effect is slight it will so alter the shape of the image that the negative is practically useless.

67. Another source of injury during enlargement (but in which the enlarger has no part) is the practice of trying to rub or scrape spots from the film. Rubbing with the thumb or finger not only produces scratches from imprisoned grit, but it also rubs oil into the emulsion, often in sufficient quantity to alter the density. This may usually be removed by careful washing with carbon tetrachloride.

68. The use of a knife or similar edge to pick out dust particles usually results in a flaw much worse than the original defect. Do not scratch at films with any kind of blade. If carbon tetrachloride, alcohol, benzene, or water will not remove a spot, just let it alone. Working on the dry emulsion almost invariably results in a worse condition than before.

Thus, although it seems impossible to make a negative wholly free from defects, it will be seen that many of these—certainly the most serious—can be avoided by using a little care in the various routine steps involved. But when the defect is found, correct it by making a new negative, if at all. This is quicker, easier, and far more satisfactory than any remedy. Reserve your attempts at remedy for those negatives which are absolutely irreplaceable.

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